AIR&SPACE

Smithsonian•December 1992/January 1993

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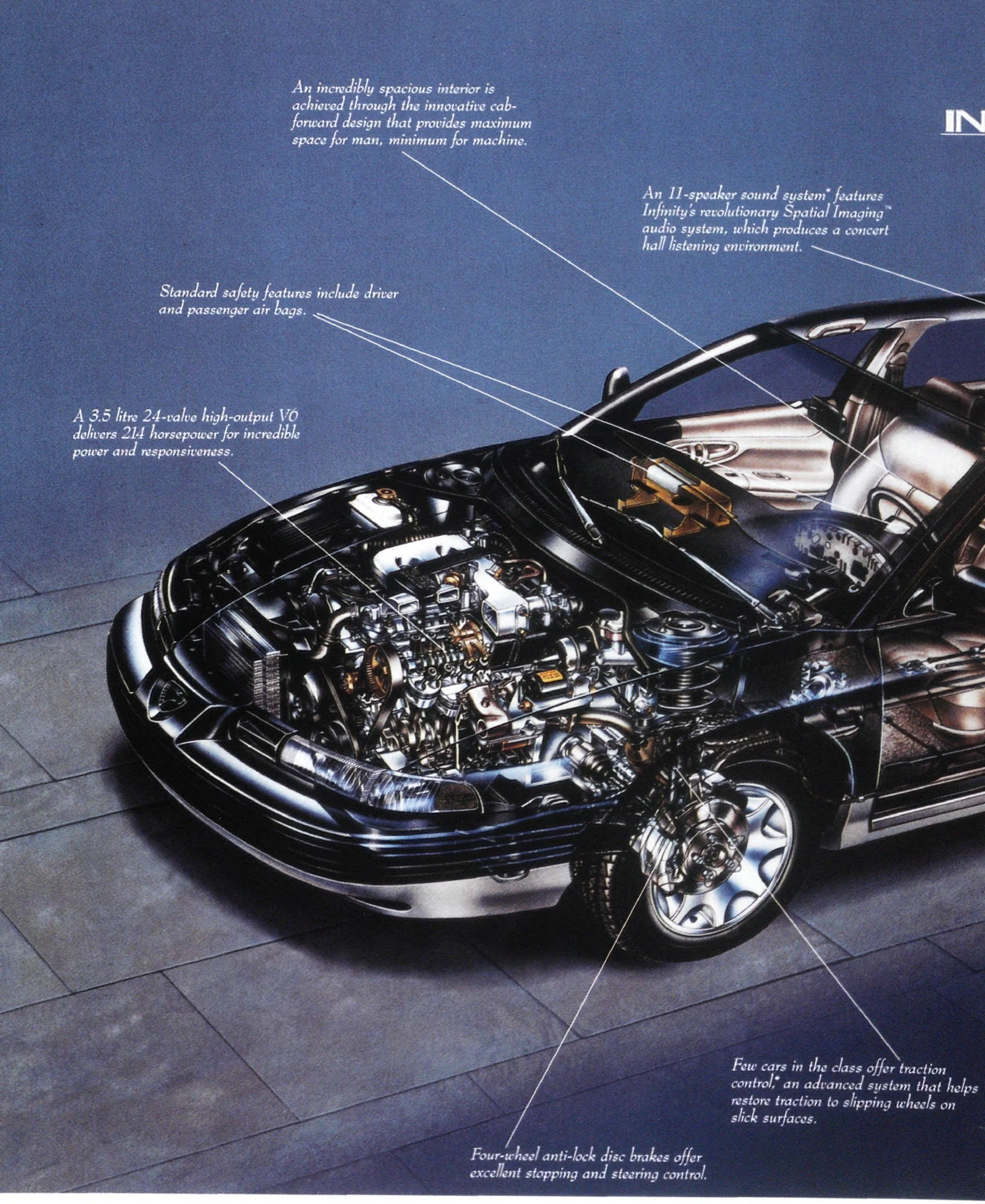

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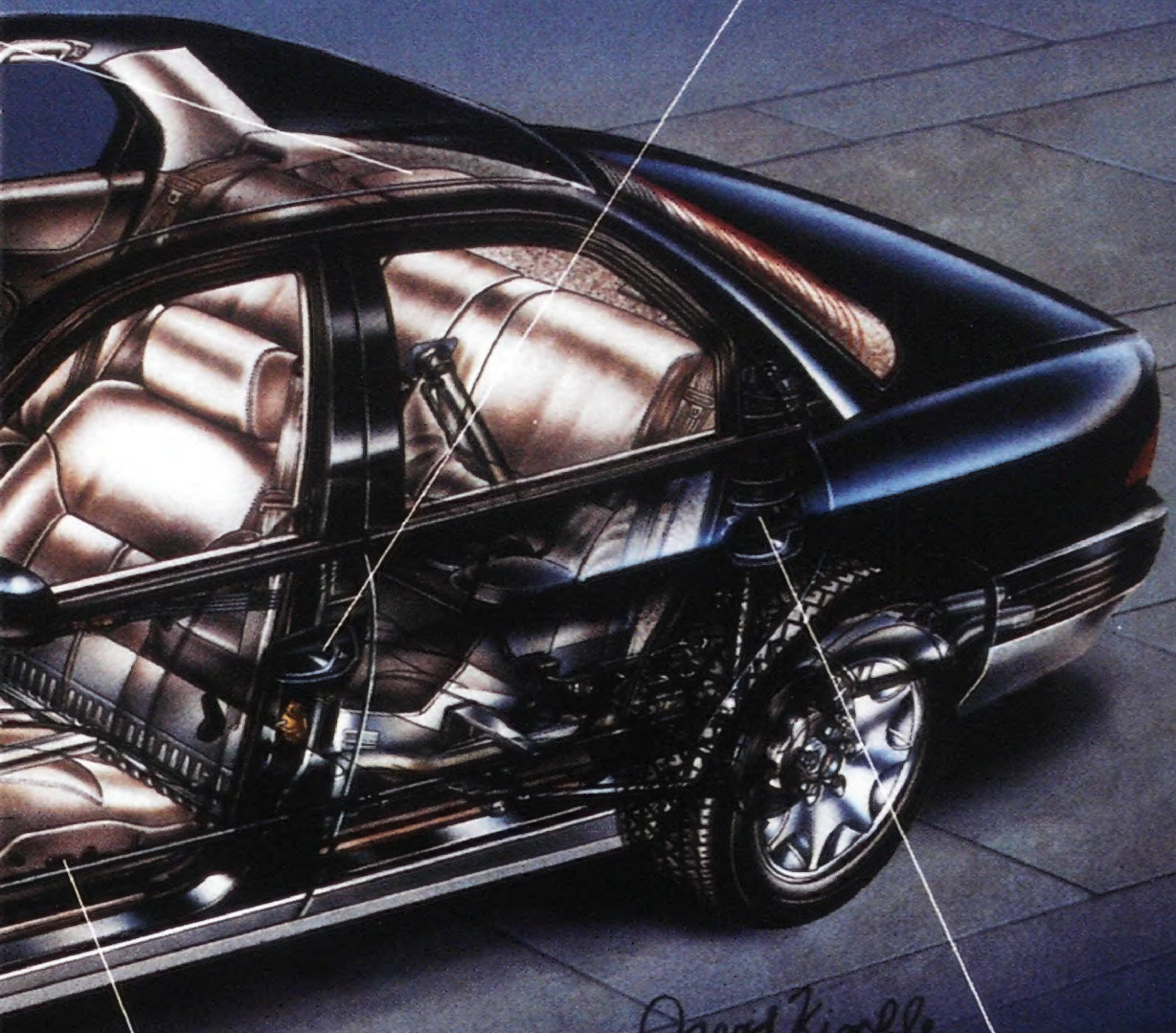

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CAROLINE SHEEN

Paul Edward Garber, 1899-1992

Paul Garber died on the morning of September 23. He had served the Smithsonian Institution for 72 years. Although he will be most remembered for having founded the nation's first collection of aircraft that can be accurately described as the property of all its citizens, the full measure of the man can be read in the decisions he made.

When the airplane was little more than a curiosity, Garber envisioned its eventual historic importance. He sought out aircraft for the Smithsonian's collection with a unique wisdom and foresight and thereby preserved dozens of artifacts that might otherwise have been lost to time and the all-too-human tendency to scrap yesterday's machine.

As soon as he learned that Charles Lindbergh had left for Paris in 1927, he cabled the flier and asked him to donate to the Smithsonian the airplane that would eventually become the collection's most revered icon.

Given the alternative of continuing to operate historic aircraft in flying condition, Garber decided to preserve them instead. He understood the power of studying—or simply contemplating—a *Spirit of St. Louis* in repose, where it exerts a more forceful hold upon the imagination.

But the final measure of Garber can be found in the flying devices for which he had the greatest affection. With his pick of galleries filled with huge metal flying machines of enormous might, all of them emblematic of human achievement, Paul Garber fell in love with the humblest of fliers: the kite. He spent hours teaching children to build and fly kites, showing by example that anyone can make something that flies.

During his life, he witnessed everything from an early flight of a Wright airplane to men making the first live broadcast from the moon. Paul Garber had seen it all. In the span of his remarkable life, his own vision of the future unfolded before his eyes.

This issue of *Air & Space/Smithsonian* is dedicated to his memory.

—The Editors

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Volume 7, Number 5

AIR&SPACE
Smithsonian

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Cover:
Bathed in the gentle light of an Arctic evening, the recently excavated wing, nose, and engine of a P-38 lie on the Greenland ice cap (photo by Louis A. Sapienza).

Departments

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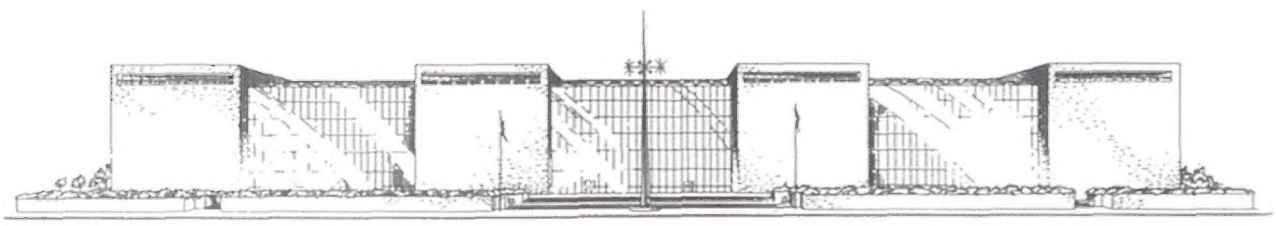

Paul Garber

It's easy to run a museum that has eight million visitors a year. What's hard is building up a collection that will draw that many people.

That achievement has to be credited to Paul E. Garber, the first curator of the Smithsonian Institution's National Air Museum, which later became the present National Air and Space Museum. Others have carried on his work, but the original inspiration came from him.

Five years ago, on my first day at work at the Museum, I was introduced to Paul. It was just two weeks before all of us on the staff gathered to celebrate his 88th birthday. By that time he had been officially retired for 18 years but still was amazingly active in his capacity as Historian Emeritus and Ramsey Fellow.

Until a few weeks before his death this past September, Paul came to work regularly, in order to go through and catalogue his papers. He had known and corresponded with all the great names in the field: Orville Wright, James Doolittle, Billy Mitchell, Glenn Curtiss, Amelia Earhart, and scores of others.

Paul's life was consumed by the Museum. During his amazing career, he single-handedly collected more than half of our collection of over 350 historic aircraft. That collection was his life's work, the Museum his obsession. During the last few years, when he no longer was able to drive, younger colleagues would take turns bringing Paul to work and taking him home in the evening. His dedication to his younger colleagues, and their devotion to him, was especially inspirational.

It is no exaggeration to say that if Paul Garber had not lived, the Museum would not exist either. Paul was collecting airplanes when others were still marveling at this curious new machine, whose future as a mode of transportation seemed quite uncertain.

In spite of an unseemly priority dispute between the Institution and the Wright brothers, in which justice finally and rightfully prevailed in favor of the two inventors, Paul was able to bring to the Museum the Wrights' 1903 Kitty Hawk Flyer, the first airplane ever to fly, the machine with which the Wright brothers had conclusively proved that manned flight was possible. Paul also received Charles Lindbergh's Ryan monoplane, the *Spirit of St. Louis,* into the collection, as well as the *Enola Gay*, which on that fateful day in August 1945 had dropped the first atomic bomb on Hiroshima.

In 1980, on the 60th anniversary of his joining the Institution, the Smithsonian officially named the Museum's collections management and exhibits preparation complex at Suitland, Maryland, the Paul E. Garber Preservation, Restoration and Storage Facility.

It often pleases me to think that, through a fortuitous circumstance, I became Paul's immediate successor in office. To honor him, if belatedly—to be precise, 67 years after he had started working at the Smithsonian—the Institution had named Paul the Honorary Director of the National Air and Space Museum for one day, August 14, 1987. As incredible as it seems today, Paul had never before been the director of his own creation. But that day in office was marked by a Presidential proclamation, deservedly making it unique in the annals of the Museum.

If it seems strange to us now that Paul should have been appointed so late in life to the Museum's directorship, it never appeared to have affected his unwavering loyalty and dedication to the Smithsonian Institution.

That loyalty also extended to children. Year after year, Paul conducted a kite festival on the Washington Mall. And each spring, when the Garber facility held its annual open house, he would come out to show kids how to build effective kites. His enthusiasm was infectious.

Paul Garber's unique vision and tenacious dedication throughout his long career culminated in today's National Air and Space Museum. We will all miss him.

—Martin Harwit is the director of the National Air and Space Museum.

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LETTERS

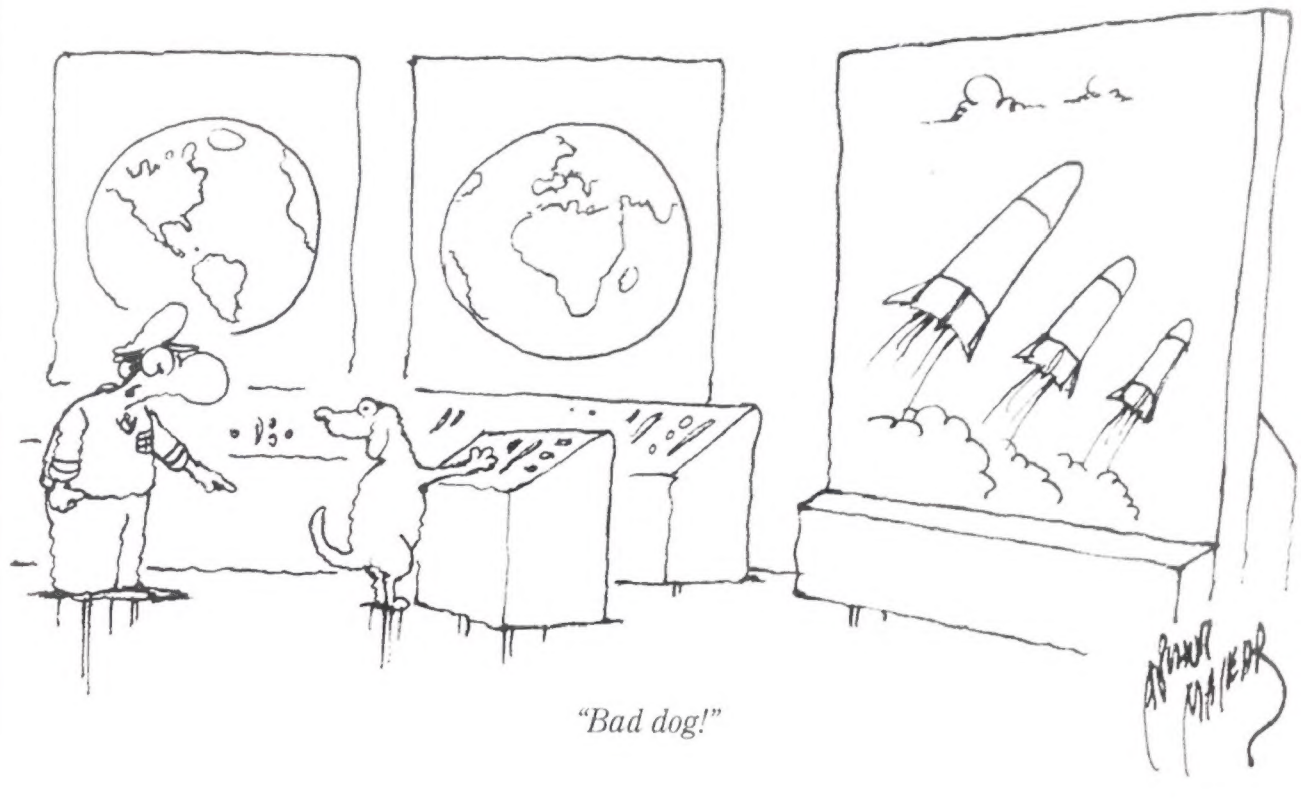
Staying Alive

"Survival 101" by Fred Reed (October/November 1992) describes a far more benign training session than the one I underwent as a Navy pilot in 1954 when I attended the Strategic Air Command survival school at Stead Air Force Base near Reno, Nevada. One of SAC's goals was to weed out anyone who might jeopardize the survival of his crew after landing in a hostile area. Fine, but I found it irresponsible that a large part of our instruction was left to washed-out aviation cadets—our guides through the rigors of a nine-day trek through the High Sierra on a minimum ration. Almost every one of these "guides" was just waiting for the instructor who had given him the "down" check that had terminated his flying career. Making matters worse were the ground rules, which often had some grim consequences. Unless you could break a bone or raise a fever of 104 degrees, you completed the course or faced disciplinary action. In one instance, blood poisoning from a severe cut might have cost a Marine Corps pilot permanent injury if we had not defied the rules and walked him back to receive medical treatment. But overall it was a valuable experience, and the Navy and Marine Corps later patterned major parts of their survival courses on SAC's program.

The most glorious moment was when it was over. Since that experience in the High Sierra, I've never found anything so snug and comfortable as a dry ditch where I could escape the wind—while the water in my canteen froze.

Captain William C. Chapman
U.S. Navy (ret.)
Atlantic Beach, Florida

I am a 14-year-old Boy Scout. Even though I live in southern California, we still learn survival skills and test them for up to seven days at a time. I would like to assure Air Force chief Chuck Lovelady, who said "nobody carries a pocketknife anymore," that about 90 percent of the 5,000 Boy Scouts in Orange County carry pocketknives. I went on two treks this summer (one in the Rockies and one in the Sierra Nevada) and for a week I put all the survival techniques mentioned in the article to use. I even ate ants, which actually taste better than the dehydrated backpacking food. Another thing is that drinking water is more important than you made it sound. If you go without water in the Sierra Nevada and other



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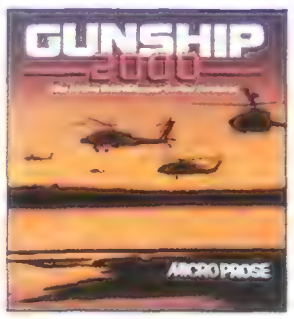

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desert ranges you can die in about six hours. One of the survival techniques I don't know about is parachuting, which looks fun (at least to a Boy Scout).

Tim Overby
Huntington Beach, California

Your Own Personal Canyon

Reading "The Battle Over the Rim" (October/November 1992) brought to mind my own encounter with the Grand Canyon. I arrived at the South Rim at dusk on New Year's Day in 1990. I had sped over winding roads and patches of ice, but by the time I reached the lookout it was too dark to take pictures. Disappointed, I walked to the railed platform, passing the last gaggle of sightseers. Their chatter died behind me as I looked out to see what I could still see. The far wall was a dim shadow against the sky, increasingly obscured by a pale mist that was filling the basin. The hulking masses of stone felt close in the gloom, standing by and listening like attentive friends, waiting for me to speak, as if I could make a sound that their silence wouldn't swallow. The silence was everything. It made me feel like I was alone on the earth. The only noise came from a breeze that washed over the nearby rocks. I stood a long while, and then the spell was broken by a twinkle of light on the canyon floor. As I walked back to my car in the darkness, I thought about returning the next day to see the Grand Canyon I'd heard so much about. But then I decided I'd found my own personal Canyon. Your article convinced me I was right.

Marcus Brooks
Austin, Texas

Aptly Named

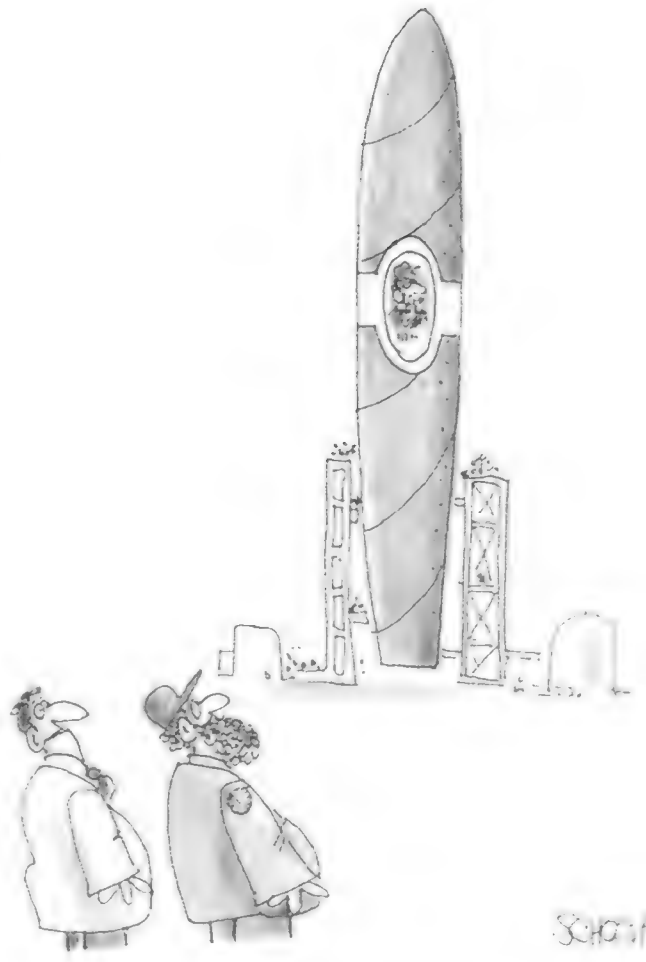
Based on its performance, I was disappointed that the B-1B wasn't named the Birdwhacker ("The Name Game," August/September 1992).

Sven Knudson
Austin, Texas

Saucer Slip-Ups

Reading the letters responding to "Aliens in the Basement" was almost as much fun as reading Frank Kuznik's article (August/September 1992), although I would have saved his piece for the October/November issue as a Halloween offering. M.M. Kazanjian of Chicago, Illinois, wrote: "It is illogical that an extraterrestrial civilization perhaps a million years more advanced technologically would design and build spacecraft that can crash." I used to think so too, but now I think it's equally illogical to ascribe technological perfection to these beings, be they real or imagined. Machines wear out, metal fatigues, electronic components fry. How many times did Scotty find himself unable to get juice from his dilithium crystals? And pilots make errors. Like the captain of a certain ill-fated oil tanker, the skipper of the Roswell disc turned the controls over to an underling, retired to his cabin, and then…well, you get the picture.

Hank Eason
Jackson, Mississippi



"We have our finest craftsmen working on it."

The Real Crop Dusters

I wish to express my disappointment with your article on aerial spraying in the agriculture industry ("This Is Bobby Yon, Altha Air Service," August/September 1992). While you may contend that the article was on Bobby Yon and not meant to describe the entire industry, I think you have done an incredible disservice to the agricultural aviation industry. Many of the readers of your fine publication have no concept of the ag aviation industry, and the picture now created in their minds will be Bobby Yon. David Savold's statement that "Bobby Yon personifies the industry's old school" is an understatement in one respect. The man is a dinosaur. But make no mistake, the difference has nothing to do with age. In every part of this country, members of the industry's "old school" are leading the way in keeping up with improved technology and modern crop production chemicals. Bobby Yon has chosen to live in the past, which is unfortunate for him but not representative of the overwhelming majority of professional ag pilots.

Yon's definition of an ag pilot is interesting, but it shows only that he disdains attending industry conventions. Leather jackets are actually few and far

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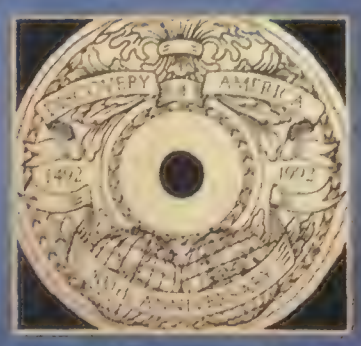

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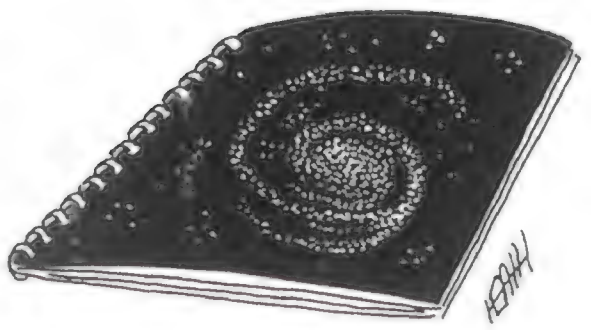

SPIRAL-BOUND GALAXY

between at state, regional, and national meetings. You are more likely to see jackets and ties on the ag pilots who attend those meetings to learn better methods of aerial application.

It is my sincere hope that *Air & Space* will consider writing an article on the aerial applicators of *today*, who are not only extraordinary pilots but competent businessmen and conscientious stewards of our environment. These are the real "crop dusters."

Rick Reed
President, National Agricultural Aviation Association
Washington, D.C.

Funding the Ridiculous

"The High Cost of Secrecy" by Steven Aftergood and John E. Pike (Essay, October/November 1992) reminded me of a sign I once saw in the office of a top executive at a large aerospace corporation: "The technical axiom that nothing is impossible sinisterly conditions one to the pitfall corollary that nothing is ridiculous." Back in the 1960s and '70s, when I was a field engineer working with aerospace companies and the government, I saw many programs I considered ridiculous. I was involved in some. And I can make a list of several going on now. I apologize to my children and grandchildren for the financial burden they are needlessly inheriting.

Frank H. Williams
St. Augustine, Florida

Sir Frank Whittle Responds

Daniel Ford's article "Gentlemen, I Give You the Whittle Engine" (October/November 1992) gives a good overall description of the development of the jet engine, as well as publicizing an important fact that has hitherto received negligible attention: namely, that the United States bought its way into a multi-billion-dollar industry for peanuts. There are, however, a number of minor errors of fact.

Firstly, I am most unhappy about the statement "A bitter man, he quit the RAF and eventually the country." I certainly had good reason to be bitter about the policies of certain senior civil servants in the Ministry of Aircraft Production and the machinations (abetted by those officials) of the Rover Company, which, I maintain, set jet development back by at least two years. But these things had nothing to do with my retirement from the Royal Air Force in 1948 or my emigration to the United States.

I had no reason to feel any bitterness toward my service; on the contrary, I was deeply grateful to the RAF for the exceptional training I received. My retirement was decided in 1948 in an interview with Marshal of the RAF Lord Tedder, with whom I had an excellent relationship. We agreed that my health was poor and that there was then no established air commodore post suitable for one who was as specialized as I was deemed to be. I emigrated to the United States in September 1976 for very personal reasons, none of which had anything to do with bitterness. A month after moving to the United States, I married a retired U.S. Navy nurse, but we had been friends since 1947. The offer of a post at the U.S. Naval Academy was added incentive to make the move.

I would also like to make the following corrections: (1) The caption on page 88 describes me as a "young businessman"; I regard that as inappropriate. (2) The date of the first run of the Whittle Unit was April 12, 1937. (3) I think my former team members would be very surprised to read that I "developed an explosive temper." (4) While it is true that I used a Benzedrine inhaler, it was not to "drive himself through 16-hour workdays." In those days Benzedrine was an over-the-counter inhaler for a stuffy nose. I had no idea that it was a stimulant. (5) Churchill did not come out of political exile at the outbreak of war. He was First Lord of the Admiralty before becoming prime minister. (6) The first flight of the Gloster-Whittle E28/39 is described as "running along the ground, trying to take off." This

Can you identify the aircraft in this photograph? From time to time the National Air and Space Museum's archives division receives photos of vehicles that its staff cannot identify. They would appreciate any help in identifying this two-seat biplane, which was probably powered by a radial engine. The structure appears to be mostly metal, although the main spars in the wings may be wood. The wingtip extremities appear to be plywood. Judging from the appearance of the buildings and the wire insulators, this photo was probably taken in Europe, possibly England. If you can solve the mystery, send your response to: Air & Space/Smithsonian, *Department ASP, 370 L'Enfant Promenade SW, 10th Floor, Washington, DC 20024.*

Last issue's photo still has not been identified. Several readers have suggested that the mysterious monoplane is a Corben Super Ace or a Fairchild F22, but Museum archivists have ruled out these possibilities.

suggests that the takeoff was labored. In fact, it was unexpectedly short—600 yards or less. (7) There was no "chase plane." It was some time later that the E28 outstripped an escort of a Spitfire and a Tempest. (8) I am mystified by the author's assertion that he visited me in Annapolis. Our meeting was here in Columbia. (9) The W2B drawings sent to General Electric were Power Jets drawings, and it was not these that omitted an oil passage. That was an oversight in the GE drawing office. (10) The first flight of a Meteor prototype, made in March 1943, was with de Havilland H1 engines—the Goblin prototype. (11) The Comet 1 was powered by four DH Ghost engines. It was the later Comet 4 that was powered by Rolls-Royce Avons.

Sir Frank Whittle
Columbia, Maryland

The Enterprise Incident

My goodness. How the years dim the memories of some people. I am referring specifically to the story about the restoration of the starship *Enterprise* model from the television series "Star Trek" ("This Old Starship," In the Museum, April/May 1992). Nowhere in the otherwise fine article is it stated that I, Richard C. Datin, a professional model maker in Los Angeles during the 1950s and '60s, happened to be the original builder of the starship, as well as a somewhat smaller version that served as the pilot model for "Star Trek" producer Gene Roddenberry. I am really surprised at all the people mentioned—Matt Jeffries, Howard Anderson Jr., and certainly the Production Models Shop crew—who failed to recognize the one person who was actually responsible for building the TV version of the *Enterprise.*

Richard C. Datin
Reno, Nevada

Ken Isbell replies: Datin constructed a three-foot prototype Enterprise *model for the first "Star Trek" series pilot. Later, when Paramount Pictures asked him to construct an 11-foot* Enterprise *model for a second "Star Trek" pilot, Datin subcontracted the work to Volmer Jensen of the Production Models Shop.*

"And this gauge measures the airline's financial stability."

Correction

The first orbital Mercury flight, which was piloted by John Glenn, was launched on February 20, 1962 ("Live, from the Cape," October/November 1992).

We welcome comments from readers. Letters must be signed and include a daytime telephone number. Letters may be edited. Write to Air & Space/Smithsonian, *370 L'Enfant Promenade SW, 10th Floor, Washington, DC 20024.* Air & Space *is not responsible for the return of unsolicited photographs or other materials.*

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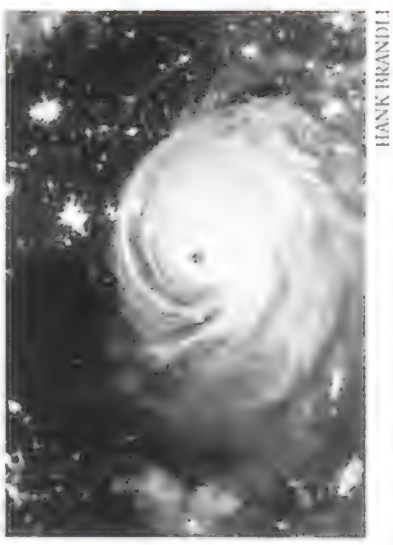
Gone With the Wind

ST. PETERSBURG TIMES

When Hurricane Andrew hit south Florida last August 24, leaving homes in pieces and lives in shambles, aviation enthusiasts were dismayed by one casualty in particular. The storm, one of the worst on record, destroyed the Weeks Air Museum near Miami. Thirty-three World War I and II aircraft that were shoehorned into the museum's hangar suffered $3 to $4 million worth of damage when the metal hangar collapsed in the high winds. Another two, left outside, were blown away. None were insured.



HANK BRANDLI

After devastating the Miami area, Hurricane Andrew descends upon the Louisiana coast with winds in its center nearing 140 mph in this Defense Meteorological Satellite Program visual-infrared composite taken from 450 miles up the night of August 25 (left). The lights of Houston lie west of and just above the eye of the storm, with Dallas to the north.

"I had built one of the most significant private collections in the world," says Kermit Weeks, the museum's benefactor and owner of all but eight of the fighters, bombers, and transports, "so it's a big setback."

News helicopters swarmed as the weather cleared, photographing the devastation. Kendall-Tamiami Executive Airport, home to the Weeks Air Museum, was so littered with twisted bits of metal there wasn't room to land. Savvy observers could pick out a wing here, a propeller there. The few airplanes that were intact had been tossed around like balsa models. Volunteers from the Valiant Air Command and the Experimental Aircraft Association, as well as other enthusiasts, rushed in from as far away as Tennessee and Wisconsin to help clean up the mess.

Weeks and his crew had only a day to prepare for the onslaught. Just a handful of the airplanes were licensed to fly, so stuffing most of them into the hangar was the best they could do. "We couldn't believe we got all these airplanes inside," says Weeks. "We closed the doors and we were real happy." The two bombers that didn't fit were tied down with three-quarter-inch rope to cleats embedded in the hangar's concrete apron.

But rope and concrete were no match for Andrew's 150-mph winds, which pushed the hangar off its foundation. "The whole thing collapsed," says Weeks. "The airplanes were all underneath the mess. The B-17 and B-23 were gone." Weeks finally found that Andrew had dropped the two bombers about a mile south. To add insult to injury, the B-23 apparently had been looted—stripped of its seats and doors.

"We're out between one and a half and two million dollars on the eight museum airplanes," Weeks says. "The rest were all mine, and I could only take a wild guess and say I'm out at least twice that." He hopes to secure a grant from the Federal Emergency Management Agency to rebuild the hangar and the museum's eight airplanes.

Weeks plans to repair all the aircraft, estimating that restoration will take a whopping 150,000 hours. "It's going to take 10 guys seven and a half years to break even," he says.

—Beth Dickey

Not With a Whimper

Pioneer Venus Orbiter bit the dust last October, succumbing to low fuel and a perturbation of its orbit caused by the gravitational pull of the sun. Launched in 1978, NASA's oldest operational planetary orbiter was designed for a 15-month mission. Fourteen years later, as PVO began its final descent into Venus' acid-laden carbon dioxide clouds, it was still transmitting loads of data.

PVO (also called Pioneer 13) reached Venus in December 1978 and explored the upper regions of the planet's

atmosphere at a time when solar activity was peaking. PVO recorded data on solar wind plasma, auroral displays, upper-atmosphere winds of up to 220 mph, high surface temperatures caused by a runaway greenhouse effect, and an area of surprisingly low temperatures in Venus' nightside thermosphere. PVO's radar also provided the first contour maps of the planet at a resolution of a few miles, revealing Ishtar Terra and Aphrodite Terra, which look amazingly like Earthly continents. (The Magellan spacecraft that just imaged Venus had a resolution of about 390 feet.)

Venus "may be an Earth gone bad," says Devrie Intriligator, director of the space plasma laboratory at the Carmel Research Center in California and a member of PVO's plasma analyzer team. "Venus doesn't appear to have a strong magnetic field. This may be what could happen to the Earth if our magnetic field switches—at that point of the switch, there will be no field. And we know from geologic records that the Earth's magnetic fields have suddenly reversed."

In the end, all but two of PVO's instruments were working when the satellite went down. As it did, PVO sent data on how Venus' lower atmosphere and ionosphere react with an influx of solar particles, studied airglow and aurora using ultraviolet observations, and looked into the very-low-frequency whistles and hoots that have mystified scientists for years to see if they are caused by lightning or plasma waves.

"We're all sorry to see it go," says Intriligator. "Through phases of the mission we've covered new ground. During the last phase it was never 'more of the same' data; it was almost like a new mission."

—Patricia Barnes-Svarney

UPDATE

Air Tours Banned

After a mid-air collision between two helicopters over Niagara Falls last September killed four people, a Canadian agency has banned low flying over the falls indefinitely and Niagara Falls officials have imposed a six-month freeze on issuing air tour licenses ("The Battle Over the Rim," October/November 1992). The Niagara Falls, New York city council will try to come up with a plan for dealing with the heavy air traffic, which residents have complained about for years.

BOEING

B-29 Birthday

JACOB VANDERMEULEN

"There won't be a dry eye on the field when *Fifi* cranks up," predicted James Edmundson at Boeing Field in Seattle last September. The retired U.S. Air Force general was addressing some 4,000 veterans of the 20th Air Force and the Korean war who had gathered to celebrate the 50th anniversary of the first flight of a B-29 Superfortress.

Fifi, the only flyable B-29 remaining, sat on a taxiway. Its crew leaned against a massive landing gear, taking the shade under its wing while speaker after speaker recalled the B-29's feats during World War II and in Korea. Due recognition was given the Confederate Air Force, which refurbished *Fifi*, the Boeing engineers who designed the bomber, and the men and women who built some 4,000 in wartime factories across the nation.

Secretary of Defense Richard Cheney hailed the dedication and professionalism of the 20th. But the audience began to grow restless, anticipating the moment when they would once again hear the Wright Cyclone R-3350 engines fire up. Most of them hadn't seen a B-29 since they were in their early 20s.

Fifi stirred up powerful memories for the veterans. Those who served in the B-29 campaigns had a sense of special responsibility. The veterans also shared sober recollections of the dangers and the friends lost, as well as regrets that their bombs brought so much harm to Japanese noncombatants.

One gunner described his role in the cramped capsule of the B-29's tail. At five feet tall, Henry Pisterzi was perfect for the job. He explained how he operated the tail guns and what it was like to always see where his B-29 had already been. He made his last Superfortress flight on a mission over Rangoon in December 1944. Different types of bombs had been improperly loaded into the bomb bays, and on release they collided and exploded, badly damaging the bombers. Of the eleven B-29s that took off on that mission, only one returned. Pisterzi bailed out over the target and spent the rest of the war in a Japanese prison camp.

General Edmundson was right. Tears welled up as *Fifi*'s four engines came to life. Even at a time when aircraft more than three times heavier than a B-29 are common, it didn't seem possible that such long, narrow wings could support a heavy bomber. As *Fifi* rolled down the runway and lifted off, the veterans reminded one another of the sights, sounds, and dangers of dozens of B-29s struggling under the weight of a full load of bombs and fuel.

With the Seattle skyline as a backdrop

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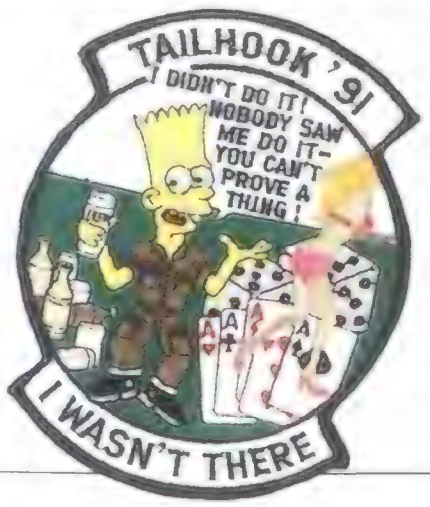
to the north and Mount Rainier to the south. *Fifi* and its supporting cast of a P-51, a B-17, a Zero, and a C-97 made three noisy flybys. It was hard to believe that this sleek craft, so contemporary in its shape and size, was a 50-year-old artifact.

—*Jacob Vander Meulen*

One of the latest patches to adorn the jackets of some naval aviators commemorates last year's scandal-plagued Tailhook convention in Las Vegas. Unsanctioned by the Navy or the creator of cartoon character Bart Simpson, the patch is often worn inside the jacket.



A Whole New Meaning to 'Nonstop'

Try to imagine a flight that would last well over half a day. No stops for fuel. No stops for *anything*. That's what they were talking about at the National Business Aircraft Association meeting and convention in Dallas last September. Example: the recently announced Gulfstream V, a bigger version of the largest American corporate jet, equipped with new BMW Rolls-Royce BR 710 turbofan engines, would fly 7,245 miles at Mach .8 in 14 hours and 18 minutes. A flight like that on a jumbo jet is one thing, but the 19-passenger Gulfstream V is no MD-11.

What do you *do* with yourself while you're winging from, say, New York to Tokyo nonstop? And what about the crew? Can pilots fly for that long without rest?

Although estimates of the number of customers interested in $30 million airplanes may vary depending on whom you ask, engineers seem confident the aircraft can be built. Gulfstream president William Lowe promised the crowd at the Dallas meeting that the airplane would enter service in 1996. The rationale for the Gulfstream and its potential rivals—Canadair's Global Express and Dassault's Falcon 9000—was implicit in the NBAA's theme, which was repeated throughout the hall: Global Vision. Association president John Olcott spelled it out in his annual report: "Pressing need for economic restructuring within the former Soviet Union provided opportunities for Western companies that could use business aircraft to cope with an internal transportation system in disarray." Olcott also cited increased travel to South America, Asia, and the Pacific Rim. And the rapidly changing political picture around the world means that formerly closed airspace is now open. City pairs that once would have been impossible to link suddenly look compatible.

The impact of airliner-size business aircraft with such unprecedented endurance was apparent everywhere. Interiors will be fitted with computers (you can't expect the chairman to spend 14 hours loafing) and complex entertainment systems (on the other hand, loafing is nice) that can run quadruple features displayed on compact, flat video screens next to each seat. A full shower in the aft lavatory allows one to freshen up. And the spare pilots will have their own rest areas just behind the cockpit so they can snooze, clear their heads, or just get up and move around.

Are we there yet?

—*George C. Larson*

UPDATE

Willow Run To Close

The plant in which Ford built thousands of B-24 bombers during the war ("Willow Run," August/September 1992) will shut down in 1993. Bought by General Motors in 1953, the assembly plant is one of 21 GM facilities slated to close by 1995.

No Noise Is Good Noise

Since the first involuntary fingers-in-the-ear response to aircraft engine noise, the most pervasive truth about powered flight is the racket it makes. Ask any pilot about this and the likely response will be "What?"

Attacking the noise problem has been like trying to carve a big turkey with a dull knife: slow and messy. Traditional "passive" techniques like muffling headsets or acoustical dampening cut noise but add weight and discomfort and do little for the poor soul living under a flight path. Now there's a real promise of quieter skies. Oddly enough, the

Astronauts who were schooled at the U.S. Naval Academy reviewed a Brigade of Midshipmen dress parade at the idyllic Annapolis campus last October. Accompanying academy superintendent Thomas Lynch and retired Air Force general and former astronaut Tom Stafford were Charles Bolden, Robert Cabana, Frank Culbertson, William Readdy, Pierre Thuot, and Daniel Bursch. With 32 of its alumni selected as astronauts, the academy has supplied NASA with more fliers than any other undergraduate institution.

tranquility will be induced by producing *more* noise: "anti-noise," as it's popularly called, or "active noise control" if you're in the acoustics business.

ANC is the modern application of an old axiom that says aiming a mirror-image sound wave precisely 180 degrees out of phase with the offending racket will produce nothing but peace and quiet. Technology caught up with science in the last decade, mainly in the form of digital signal processors that can analyze a sound and immediately introduce a signal that cancels it. The process was initially used in quieting industrial ventilation ducts and later used in automobile mufflers. Now, with computers calculating ever more complex algorithms and with piezoceramic actuators embedded into structures like aircraft fuselages to control vibration, anything that shakes or squawks is a target. ANC will soon be hushing everything from cars, dishwashers, and vacuum cleaners to cockpits, cabins, and airports.

The first excitement came when the Bose Corporation sent prototype ANC headsets on the round-the-world *Voyager* flight in 1986. The headsets house sensors and microphones that detect and cancel out irritating low-frequency engine noise while ignoring voice and music. Even at $995 a set, Bose initially had a five-month backlog of orders for the 19-ounce units.

Active Noise and Vibration Technologies' headsets are "open backs," like lightweight stereo headsets, that the aeronauts on the round-the-world *Earthwinds* balloon will be able to wear even while sleeping. ANVT's five-ounce headsets will hit the market early next year, with an aerospace-rated system for under $500. And, says ANVT president Tom Hesse, "Headsets could be installed in the armrests of these 10-seater turboprops to cancel the sound; if you've flown in them you know it takes two days to get your hearing back." ANVT is also working on cabin-wide quieting, which employs several strategically positioned flush-mounted speakers to create zones of quiet and may show up in 15- to 100-seat turboprops next year.

Controlling external noise problems around airports is about five to ten years away, guesses Ricardo Burdisso, an assistant professor at Virginia Polytechnic Institute's vibration and acoustic labs. VPI, with the help of NASA Langley Research Center, is working on reducing the persistent whine from the inlets of ultra-high-bypass turbofan engines. "We haven't solved the problems," says Burdisso, "but we have demonstrated that using active control is a feasible approach." As one aerospace engineer put it, "We have it all: the engine noise, systems noise, duct noise, hydraulic

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pump noise, vent fans noise, pressurization valves noise. There's a whole pageful of opportunities where ANC will help."

—Thomas Bedell

UPDATE

NRO Goes Public

The National Reconnaissance Office, classified since its inception but now threatened by a reorganization of U.S. intelligence agencies, has acknowledged its own existence ("The Spies in Space," December 1991/January 1992). A press release issued last September defines its role as "the single, national program to meet U.S. government intelligence needs through spaceborne and assigned airborne reconnaissance." Recent reorganization plans in the House and Senate have called for incorporating the NRO into other agencies or folding it outright.

Big

Every schoolchild knows that what goes up must come down. But according to a helium balloon manufacturer in Texas, there's no reason to rush this "must come down" business. Winzen International in San Antonio says that a balloon the size of the Astrodome could remain in the stratosphere for several years, providing a long-term research platform for atmosphere-monitoring instruments and telescopes.

Current research balloons, which reconnoiter heaven and Earth from altitudes of up to 26 miles, can remain aloft for a few days at most latitudes, or a few weeks in the frigid, buoyant air over the poles. But Winzen's balloons, which will be some 300 feet in diameter, should stay airborne for at least four years "and theoretically they should float for up to 40 years," says Winzen president James Rand.

Current designs, called zero-pressure balloons, alternately vent helium and drop ballast as the temperature rises and falls. After a few days there's not enough helium to maintain lift. Engineers have tried making balloons of thin Mylar film, but the material develops microscopic tears and pinholes.

Winzen, with funding from the Defense Advanced Research Projects Agency, selected something called biaxially oriented nylon for its new super-pressure balloon. The material, a thin plastic film developed in Japan, is tough, flexible, and impervious to the supercold temperatures at high altitudes. In addition, Winzen devised a new technique for sealing the 200 or so panels that form the balloon to prevent the seams from bursting.

A 76-foot-diameter test balloon made a successful flight from Alamogordo, New Mexico, last October. "It was as tight as a tick," Rand says. If all goes well, the first jumbo long-duration balloons could bob skyward early in 1993, and if Rand's design works, some could stay airborne until the next century.

—Damond Benningfield

WINZEN INTERNATIONAL

Notes From an Astronaut Watcher

The Association of Space Explorers had its annual get-together in Washington, D.C., last August. Usually this fraternity of past and present astronauts and cosmonauts meets in far-flung locales like Hungary and Saudi Arabia, but here they were at the Georgetown University Conference Center. I suppose die-hard baseball fans would go to the ends of the earth for an oldtimers' game. For me, attending this gathering of men and women who had flown beyond the atmosphere was a chance to bask in the glow of history.

Inside the conference center were about a hundred space travelers. I spotted familiar faces: Apollo veterans Jim Lovell, Tom Stafford, and Stu Roosa, who orbited the moon, and Pete Conrad, who walked on it. But the less familiar ones intrigued me more. There was Scott Carpenter, who hardly ever shows up at these gatherings,

wearing a business suit and cowboy boots. Valentina Tereshkova, the first woman in space, was also in attendance, as were Alexei Leonov, the first spacewalker, and a handful of other cosmonauts who have spent not days but months in orbit. There were also a score of shuttle veterans, most of whom I barely recognized. None of them looked like space explorers; they reminded me more of high-mileage, middle-aged corporate executives.

At one point Konstantin Feoktistov was addressing the group. In 1964 this engineer and designer crammed himself into Voskhod 1 along with two other cosmonauts for the first three-man spaceflight. Now he was supposed to be expounding on "Why Explore Space?" Instead, he launched into a treatise on the expansion of the universe that only a cosmologist could love—or comprehend. After 15 minutes I headed for the lobby, where an astronaut confided, "He does this every year." I returned for Tereshkova's presentation on "The Human Experience," but she was talking about Mars probes instead.

In the hall, between presentations, I saw Toyohiro Akiyama, the Japanese journalist who in 1990 became the first member of the fourth estate in space, aboard the Mir space station. I'd heard he spent nearly as much time complaining about space sickness and nicotine withdrawal as he did describing his experience, but when he spotted Leonov they embraced like old army buddies.

Tom Stafford wrapped up the day's public session with a talk about the fiscal and political realities of making space policy in Washington. The following day there would be closed-door discussions on future ventures. Then the crowd would head for a resort in the West Virginia hills for some R&R. Would they regale one another with stories of the cosmos? Would they share the special burdens of historical figures? Maybe they talk about the same things as everyone else—the office, the kids, the last vacation.

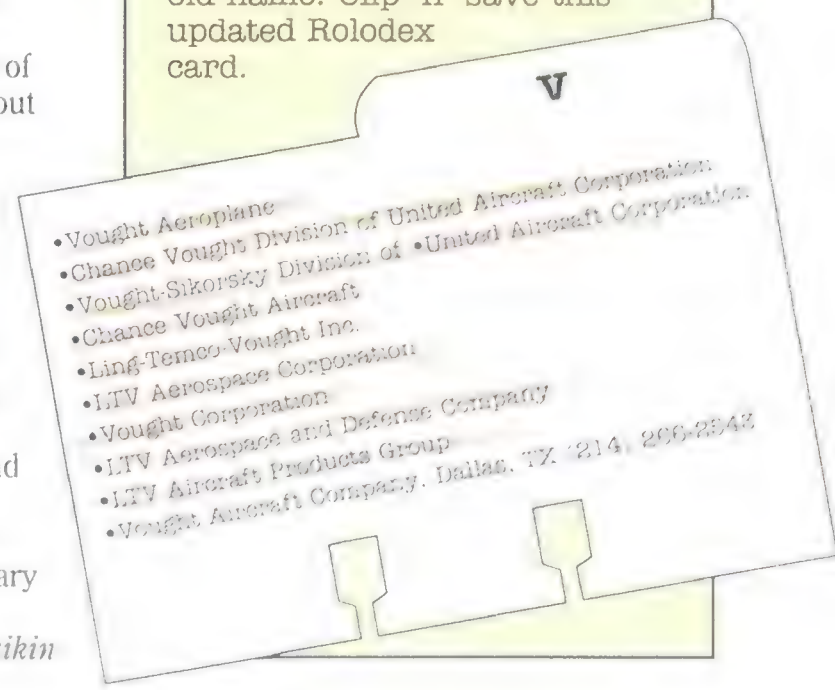
In the lobby of the Georgetown University hotel, the wives of the cosmonauts were returning from an all-day shopping marathon, laden with bags from K-Mart and Payless Shoes. A few of the astronauts and cosmonauts had changed into weekend clothing. Here and there, pocket cameras hung from wrists. And there didn't seem to be anything extraordinary about them at all.

—Andrew Chaikin

UPDATE

That's "Vought," as in "Bought"

Last August the aircraft division of LTV Aerospace and Defense was sold to the Carlyle Group and Northrop Aviation Corporation (Soundings, October/November 1991). Along with a new owner, it got an old name. Clip 'n' save this updated Rolodex card.



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DO-IT-YOURSELF BIRDHOUSE

Even in retirement, the National Air and Space Museum's SR-71 Blackbird, the fastest jet ever to fly, has a powerful effect on people. It recently inspired MIC Industries of Reston, Virginia, to donate 30 tons of steel and the use of the company's Automatic Building Machine to construct a shelter for the aircraft. Ten other northern Virginia companies pitched in equipment and services, and 18 aircraft restoration specialists from the Museum's Paul A. Garber facility became instant construction workers.

CAROLINE SHEN (2)

The arches that the Automatic Building Machine (inset) produced for the Blackbird shelter weren't golden, but they saved the Museum almost $100,000.

Ever since the Museum acquired the SR-71 from the Air Force in March 1990 (see In the Museum, June/July 1990), the airplane had sat outside a storage hangar in a backyard corner of Washington-Dulles International Airport. The exposure of the airplane's sensitive titanium skin to sun, rain, and the pollutants drifting around the busy airport was a great worry to Al Bachmeier, the chief of the Museum's collection maintenance division. "We haven't seen any corrosion of the titanium yet," says Bachmeier, "but we have noticed some corrosion of steel washers and engine parts. You know, this airplane had never sat outside in its whole service life. No one could tell us what would happen to it or how to care for it. We have military plans for the C-130 [another Museum-owned aircraft parked outside at the airport]. But not this one."

On the very hot last day of August, MIC Industries came to the rescue with its Automatic Building Machine, a remarkable piece of equipment that can transform almost any group of 10 or 15 people into a construction crew. The ABM crunches sheet steel into reinforced arches, which can then be joined and turned into a building—frequently in a single day—by people with no previous building experience. The machine is marketed widely in non-industrialized countries and saw a lot of action in Florida and Hawaii this summer building emergency shelters after the devastation of hurricanes Andrew and Iniki.

By early afternoon Bachmeier and 12 other restoration specialists had put up the first few arches of the Blackbird's new home. The arches formed a theatrical backdrop for the ongoing construction work, gracing the mangy strip of airport property like a mini-St. Louis gateway. Lin Ezell, the Museum's assistant director for collections management, watched the crew working. Over the slamming of metal and the clamor of the Automatic Building Machine, she shouted, "If we'd gone through the traditional design and construction process, this project would have been about $100,000. As it is we've spent about $5,000 and the rest has been donated."

Thirteen construction workers took their places, spaced more or less evenly along a 90-foot strip of steel. The steel had been fed through the ABM, which folded it along its long edges so that it would connect with adjacent strips. Now it was being fed through in the opposite direction, becoming convex and corrugated in the process. The workers walked along with the 500-pound strip as it slowly passed (at 50 feet a minute) through the crimping mechanism. On the other side, they accepted its weight gradually as it glided from the end of the machine. Then they carried it to a staging area where they had already joined two other strips.

"They get three put together and then the crane lifts it and puts it in place, so obviously they have to have a very skilled crane operator," Ezell said. The crew steadied the arch as the crane slowly pulled it upright, their outstretched arms pushing as the crane lifted, making the construction project look like an industrial barn-raising.

Then the crew reassumed their positions along the ABM and, looking a little played out in the afternoon sun, started the carrying-and-connecting routine all over again. There would be plenty of sore muscles at the Garber facility over the next couple of days.

"At about this time next week we'll wheel the airplane in," Ezell shouted, "and

we'll put up the other end wall and all it will have is a personnel door. [The Blackbird] will be more or less entombed."

By 7:30 that evening all the arches were in place and seamed together, making good on MIC's promise to shelter the world's fastest airplane with the world's fastest mobile construction system. It took another month, however, to install end walls, electricity, smoke detectors, and ventilation and security systems.

Now that the SR-71 is under cover, only two of the Museum's aircraft are homeless. "[The Blackbird] was the highest priority because the construction of the aircraft does not lend itself to exterior preservation like the C-130 and the Super Constellation [airliner] do," Ezell said in August, gesturing toward the trio of aircraft huddled outside a locked hangar. Of the three, the Blackbird was clearly the aristocrat, looking potent, superior, and worth all the trouble being taken to protect it.

—Linda Shiner

March on Washington

Go-For is a bright mustard-yellow contraption that rides on four wheels and stands barely 20 inches tall. It was designed to traverse the surface of Mars, but last August the little rover could be found rolling across a short stretch of the nation's capital. The occasion was the opening ceremony of Rover Expo (officially, the International Space Year Exhibition of Robots for Exploring New Worlds), and it offered, among other things, the rare sight of space robots parading down the Mall.

CAROLYN RUSSO (2)

Marsokhod

Rocky III

With the words "Gentlemen, start your rovers!" the parade got under way. Hosted by NASA, the Planetary Society, and the Museum, the two-day event was billed as the world's largest gathering of interplanetary rovers. Sixteen rovers were in attendance, an assortment of walkers, crawlers, and wheeled creatures that ranged in size from four pounds to three tons. The primary purpose of the Expo was to encourage public interest in sending robotic explorers to Mars.

Spectators lined the parade route, which stretched 500 feet—from the east end of the Mall to a tent that had been pitched a block east of the Museum. A red carpet awaited the robotic drill team at the tent entrance. The robots had been arranged according to size, and leading the charge were the micro-rovers: Go-For, MITy, Dixie, Rocky III, Raybot, and Marsokhod, a Russian participant. Bringing up the rear was the parade's quasi-float: the Mars Balloon—a piece of plastic filled with helium—and its soil sampling device. The more leisurely gaits of some of the other rovers, one of which moves at the stately pace of 18.72 inches a minute, kept them out of the parade.

"Good morning ladies, gentlemen, and robots," said Museum director Martin Harwit, after all the rovers had arrived inside the tent and dispersed to their stations. The tent and its fervent Mars-or-bust atmosphere suggested a revival meeting. "Is there life on Mars? Maybe not now, but there will be!" NASA's Richard Petersen told the assembly.

The audience sat in bleachers facing what appeared to be an oversized sandbox. Digital data from the Viking mission had been used to prepare a 24- by 40-foot simulation of the Mars surface using clay and foundry slag. According to the organizers, the rusty orange color was an extremely accurate rendition of the Martian soil's appearance.

Over the next two days, the rovers took turns frolicking on the faux Mars surface. The micro-rovers seemed to have the greatest appeal; children in the audience treated them like pets. Spectators kept their distance, however, from a six-legged, 12-foot-tall walking robot named Ambler, which moves like a pile driver doing an awkward waltz (see "Getting Around on Mars," June/July 1991). One misstep by Ambler and it would have been "*hasta la vista*" for a micro-rover.

Rover Expo drew more than 8,000 spectators during the two days of demonstrations. While the rovers showed off their abilities to maneuver, speakers pointed out why robots are useful for planetary exploration. As Martin Harwit observed, "They never get homesick."

—David Savold

Museum Calendar

Except where noted, no tickets or reservations are required. To find out more, call Smithsonian Information at (202) 357-2700; TDD: (202) 357-1729.

December 3 General Electric Aviation Lecture: "50th Anniversary of the American Jet." Lt. Gen. Laurence C. Craigie (ret.), the first U.S. military jet pilot, and Ann B. Carl, WASP pilot. Langley Theater, 8 p.m.

December 5 Monthly Sky Lecture: "Star Gazing for Beginners." Jim Sharp, NASM, Einstein Planetarium, 9:30 a.m.

December 12 Gallery Opening: "Where Next, Columbus?" A look ahead to the next 500 years of exploration, examining some of the possibilities for future space travel. Gallery 209.

January 8 "Frontiers on Film." Space fiction film series, first showing. Langley Theater, Fridays at 8 p.m.

ARTIFACTS

MARK AVINO

A bust of Eugene Jacques Bullard, the first American-born black combat pilot, was unveiled at the Museum in October. Sculpted by Eddie Dixon and donated by the McDonnell Douglas Foundation, the sculpture is on display in the World War I gallery.

January 14 General Electric Aviation Lecture: "Emily Warner's Frontier Flight." The first female airline pilot for a U.S. carrier will describe her experiences with Frontier Airlines. Langley Theater, 7:30 p.m.

New IMAX Film *Fires of Kuwait.* A documentary about the massive effort by firefighters to extinguish more than 700 oil wells that were ignited by retreating Iraqi soldiers in 1991. Langley Theater, daily at 6:45 p.m. Visitors may purchase combination tickets for this film and the 6 p.m. IMAX feature, *Antarctica.*

Star Trek How to Obtain Passes: The exhibit will run through January 31, 1993. All visitors, regardless of age, must have passes to enter. Free same-day passes (four per person maximum) may be obtained at the Museum. Advance passes may be obtained for a fee through area Ticketmaster outlets or by calling (800) 551-7328. For recorded information, call (202) 786-2122.

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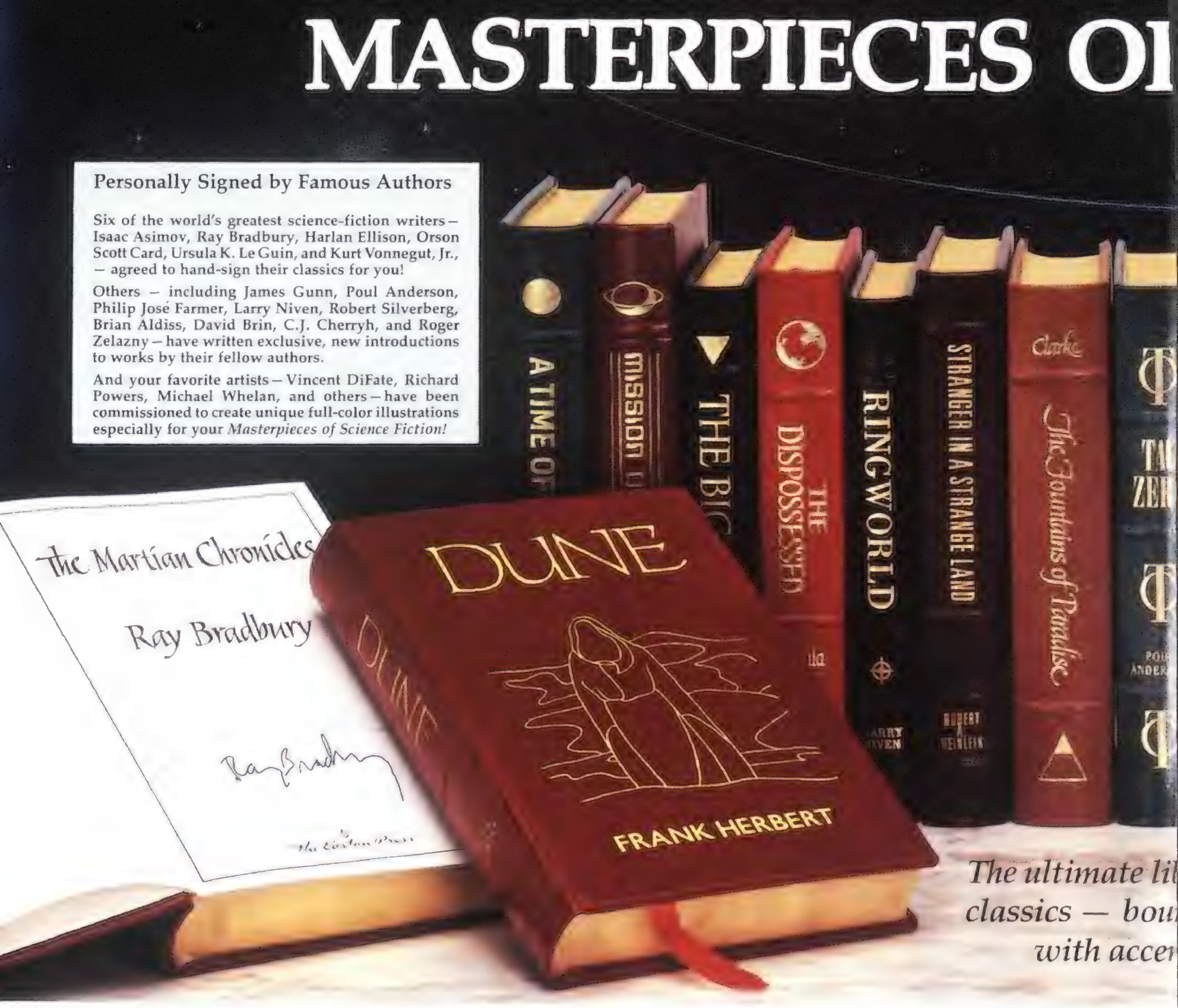

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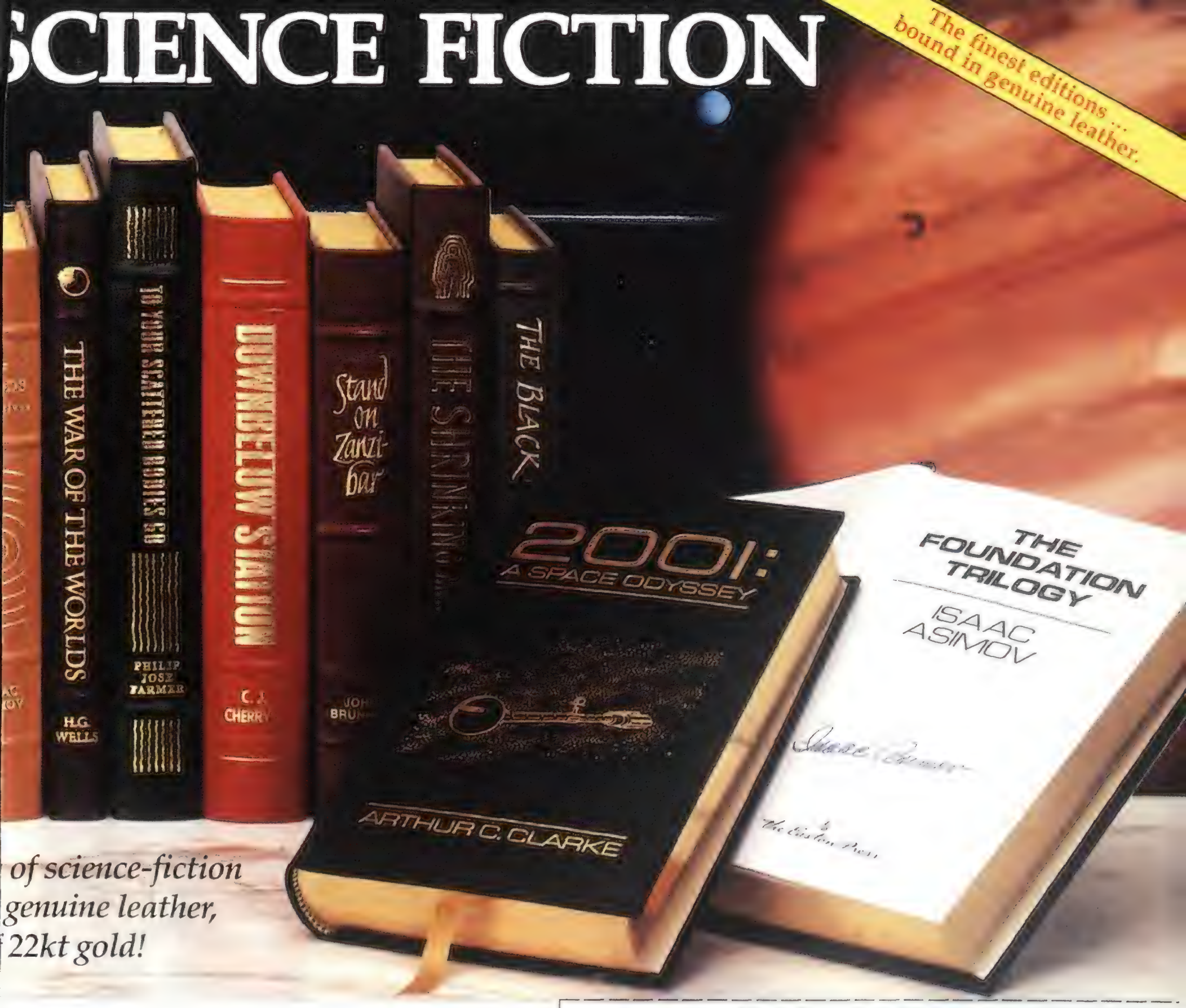

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SIR RICHARD'S WILD RIDE

It was sometime in the 1930s, following the court-martial of controversial Air Force leader Billy Mitchell, that General Hap Arnold wrote, "It is well to avoid a reputation for eccentricity."

There is no doubt that the general, writing about the military profession, had a point. Nevertheless, when I joined the Royal Air Force in 1950, it was still possible for some officers to be both distinguished and outlandish. Several senior RAF officers had colorful backgrounds, but for me, Air Marshal Sir Richard "Batchy" Atcherley was in a league of his own.

Batchy (a confirmed bachelor) made a career out of being outrageous. In his earlier days he had gained the spotlight as a Schneider Trophy pilot on the winning 1929 RAF team, but even then one of his more notable achievements was placing a dead porpoise in the beds of several Italian team members, one after another. Later, as a squadron leader in the 1930s, Batchy was flying a Miles Magister along the English coast when he caught sight of an aircraft carrier in the channel. On the spur of the moment he decided to call on the Royal Navy for tea. It was the first deck landing he had ever attempted, and as he touched down unannounced, the carrier's aircraft elevator was being lowered and the Magister fell through the gap in the deck. Batchy necessarily stayed for tea while the captain sent a signal to the air ministry to the effect that Squadron Leader Atcherley was a welcome guest and would be returned in good order in a week or so, when naval exercises in the Bay of Biscay ended.

I met Batchy in 1958, when he was my commander in chief. It was his last year in service, and Batchy had decided to spend some time saying farewell to his friends in various air forces around the world. I was asked to join the team of four that would accompany him on his visit to Italy.

We duly assembled at Blackbushe airfield, near London, on the appointed day. The air marshal's Devon, a twin-engine executive aircraft, and its chauffeur were waiting on the apron.

When Batchy arrived, he told us to get his Meteor 8, a single-seat twin-engine jet fighter, out of the hangar. The Devon pilot looked horrified. For all Batchy's great abilities, it was generally acknowledged that he had never fully accepted that flying a jet was different from flying a piston-engine aircraft.

Since I was then current in the Meteor, I got the job of preparing the flight plan. The Meteor 8 had no navigation instruments apart from a compass, so accurate headings and times were important. We were aiming for Turin in northern Italy, but the short range of the Meteor mandated refueling somewhere. I picked the French military airfield near Dijon as a likely spot.

The air marshal was keen to be off. By the time I had his maps ready, he was strapping in. He seemed to bulge out of the small Meteor cockpit and his brass-rimmed pince-nez looked incongruous perched on the end of his nose. I stood on the wing and briefed him as best I could, but he was impatient with details, paying more attention to major visual checkpoints (like the English Channel) than to radio frequencies or altitudes and headings to fly. I realized that he was not comfortable with the notion that he should fly a jet above 30,000 feet to conserve fuel, nor did he much like flying above a cloud deck. He preferred to stay in visual contact with the ground so that he could read a map and see where he was going.

We waved him off and then rushed for the Devon so that we could get airborne and monitor his progress via radio. An hour after takeoff we heard a faint but imperious voice calling Dijon tower. We were receiving only his side of the exchange but we could imagine the rest.

Batchy opened by firmly telling the tower to find someone who spoke English. He then asked for a description of the airfield. Evidently he had a field in sight but was not sure which it was. Rapidly tiring of the French controller's responses, and by now low on fuel, Batchy announced that he would make a low pass by the tower to settle things.

There was a short pause, then Batchy

asked, "Did you see me?" The answer was apparently "non," because he then demanded a heading to the military field. It turned out he was over Dijon's civil airport, where the controllers were doubtless in something of a turmoil.

Batchy reached Turin in due course, in high good humor after a tour of the Alps. The next leg would take him to Rome.

By morning, the weather had turned unfriendly. Heavy rain lashed northern Italy and the clouds were thick, with the bases at only 500 feet and the tops reported above 20,000 feet. After lunch, when the time came to leave, things had not improved. Batchy was irritable but intent on flying himself to Rome. We sat in the terminal, watching the rain and waiting for him to give in.

He never did. Late in the day I was gazing miserably through the misty terminal window when I saw activity at the far end of the apron. With a yell at my dozing companions, I ran out into the downpour and raced toward the Meteor.

I could see the burly figure of Batchy struggling into the cockpit, waving his arms at some anxious-looking ground crew. His voice reached me 50 yards away. "Dick!" he bellowed, "Get these ruddy idiots off my aeroplane!"

There was no arguing with him. He had made up his mind that it was time to go, bad weather notwithstanding. I strapped him in, found his maps, and got "Yes, yes, don't fuss!" when I tried to remind him about climbing to altitude, steering accurate headings, and using the radio. He started up, waved away the chocks, and taxied out. His arthritic right leg must have been acting up because he responded to the marshaller's signal to turn left by completing a 270-degree turn to the right under full power, blowing the unfortunate man off onto the grass. The Meteor had hand brakes, with the rudder bar controlling the amount of braking to each wheel. Applying left rudder in that small cockpit inevitably meant bending the right leg as the left one extended. It was apparent that Batchy's right leg would not bend and that left rudder was precluded. I prayed that if he lost an engine in the air, it would be the left one.

We gathered by the Devon to watch the takeoff. The Meteor disappeared into the rain, flying level at 400 feet or so. By the time we got airborne some ten minutes later we could not contact him, a fair indication that he was still flying at a very low altitude.

When we reached our scheduled stop at Lecce it was already dark. In answer to our query about the air marshal's whereabouts, the Italian base commander called Rome. Batchy was not there and the Italian air ministry was frantic with worry. Nothing had been heard from the Meteor since it had left Turin. They had no idea what had happened to him.

At eight the next morning they still had no idea. A full-scale search was in progress, but the worst was feared. Just before nine Batchy called, wanting to know if we had reached Lecce intact. He sounded surprised that there should be any concern for his welfare.

Apparently he had stayed below the clouds and flown to the coast near Genoa, aiming to follow the shoreline until opposite Rome. He got interested in the fishing villages on the way and flew around a few, admiring the little harbors. After a while he realized that it was really quite dark and that his fuel was dangerously low (he told us that his tanks had obviously not been full when he took off). He was not sure where he was and could not raise anyone on the radio (he told us the stupid thing wasn't working). Soon the ground was in darkness and his tanks were nearly dry. Just then, he saw a line of lights that he thought might indicate a runway. It was only a single line, but it would have to do. He made an approach and slammed the Meteor on the ground, keeping the lights to the right. It was a grass surface and the aircraft slithered alarmingly under braking, but he finally got it stopped.

Batchy switched everything off and slid back the canopy. He saw that the Meteor's nose was in a hedge at the edge of the field. People were running toward him, shouting in Italian. "Does anyone here speak English?" he demanded.

The villagers were very pleased to see him. He had landed on their flying club airfield, which was little more than a pasture, and they had never seen a jet aircraft up close before. They took him to an inn and gave him the best room in the house. He had a splendid meal and then asked about a telephone. They had only one in the village, and it was out of order. Full of chianti, he told them not to worry and went to bed.

Next morning Batchy had a sumptuous breakfast and then begged a lift to another village where there was a working phone. His resurrection was regarded with a certain amount of awe by the Italian authorities, especially when they saw where his Meteor was and that it was unscratched. All was forgiven in the wonder of his achievement.

Batchy's entire career was like that. He rode his luck with his talent, believed that nothing was too difficult, and never took no for an answer. It would be good to think that there was room for one or two characters of his sort in a modern air force, but I suspect that a man like Batchy would not have been happy in this age of electronics and computers. He really liked to hold a map in his hand and see where he was going.

—Air Vice Marshal Ron Dick (ret.)

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T Minus Me

In the 1960s, ours was an outer space family from the galaxy Midwest. Dad worked at McDonnell Aircraft, the biggest employer in St. Louis, and rocket lore propelled our childhoods.

Those were heady days. McDonnell was putting together the Mercury capsules, then the Geminis, and finally working on the Apollos. Each week I snatched Dad's copy of *Aviation Week & Space Technology* before he could get to it. We reveled in each lap of the space race, and we never missed a manned launch.

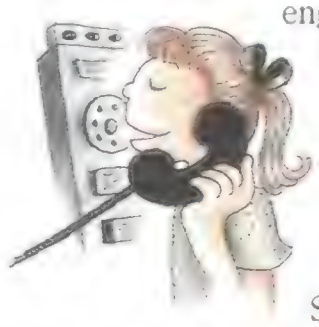
Launch days united our family. Aeronautics seemed our only reliable link with our father, whose job included editing transcripts of the dialogues between mission control and the astronauts. He was usually a distant planet to us, but on launch days all six of us orbited the rabbit-eared Motorola, in thrall to the countdown.

I was 13 when I discovered that not all American families sat entranced before their TVs when a launch was under way. We were gathered one Saturday afternoon in 1965 monitoring Gemini 7's countdown, which had reached T minus 15 minutes and counting. My little sister and youngest brother, not much more than a toddler, watched from the bunker of a half-unfolded sofa bed. My other brother and I were sprawled on the living room floor. Mom was in the rocker and Dad sat in his easy chair.

Tension was building—we'd been through a couple of delays already. (I marveled at how easy it was to delay a monumental thing like a launch. Flight director Chris Kraft would announce, "We have a delay" and the clock would stop. I assumed he was a very powerful figure.) But now the count had resumed, and we were fidgeting and anxious.

Then the phone rang. My father rose and walked into the bedroom. When he returned, he said tersely that it was for me.

I didn't usually get phone calls. Half curious and half irritated, I went to the phone. My attitude changed abruptly when I discovered it was Becky Jennings, a girl in my eighth grade class whom I had a crush on. She had discovered a broken pay phone that allowed free calls, and I was first on her list.



"Becky, there's a liftoff about to happen," I said.

"What?"

"A liftoff. A launch. There's a rocket about to take off." My unspoken question was *Why aren't you in front of your TV?*

She seemed puzzled. "Oh, you watch those?" she asked airily.

Now I was on the horns of a dilemma. I liked Becky Jennings. But I had to see the launch. And I knew that my family was waiting in the living room, within earshot, wondering how on earth I could be on the phone with a launch imminent.

Becky showed no signs of ending our talk—her talk, actually—which rambled across the teenage firmament. The day before, she was almost caught passing a note in class. The cafeteria food was terrible. An older sister was going somewhere with her boyfriend.

From the living room my brother shouted, "T minus nine minutes!"

I squirmed. "There's nine minutes to launch, Becky," I said. But clearly she was not going to take the hint. She was planning a trip to Northwest Plaza, the brand-new shopping mall. Wasn't Illya Kuryakin, one of the men from U.N.C.L.E., adorable?

I knew my father was about to go ballistic himself. Ours was not a household where one hung on the phone, at least not when Dad was home. If the oldest child's role is to push the envelope of parental tolerance, I was poking a hole in it.

"T minus five minutes," said my brother.

From the phone booth Becky spotted someone driving past that she thought she knew.

It seemed distinctly possible that Becky was going to talk right through the launch and I was going to miss it. My family would be shocked if I was absent when Cape Kennedy intoned, "five…four…three…we have ignition…." Then would come those fateful few seconds when vapors swirled, we all leaned forward, the engine cones inched away from the pad, and launch control added dispassionately, "We have liftoff."

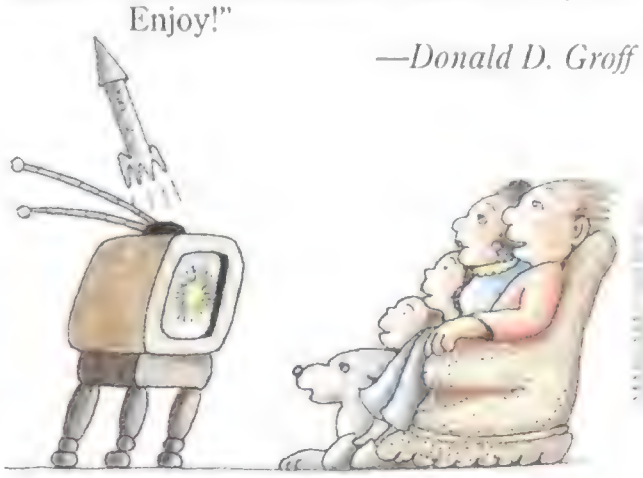
Liftoff. The closest our family came to collective joy and exhilaration. I knew when we achieved liftoff that Saturday because I could hear it in the next room. Gemini 7 took off and I suddenly lost my appetite for Becky's company. I told her I had to go, then walked into the living room. I might as well have slithered in on my belly.

"It took off," my brother said. Nobody hollered at me. Nobody said much of anything, in fact, but I could feel how astonished they were that I had not been there. I sat with them and watched the replays, but of course it wasn't the same.

A couple of weeks later another Gemini was launched. I sat glued to the TV, as if doing penance. Eventually the onus of my dereliction faded. The Gemini program gave way to Apollo. My romance with Becky bloomed and withered. A year after Apollo 11 we ended up at the same college. She left for the Navy, I later heard.

I wonder if there are families that make a ritual of watching shuttle launches—the few that are televised. I doubt there's much angst over missed liftoffs. Probably just a Post-It note on the refrigerator that says, "Honey, we taped the launch for you. Enjoy!"

—Donald D. Groff



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ICED

Every airplane that survived World War II could tell a tale. But few would rival the story of Harry Smith's P-38.

by Karen Jensen

Photographs by Louis A. Sapienza

Lieutenant Harry L. Smith had a 23-year-old's knack for popular expressions and a military pilot's level head. Before attempting to land his P-38 on a forlorn stretch of the Greenland ice cap, he flew over another pilot's Lightning, which had just slammed over on its back in the slushy summer snow. Smith was searching hopefully for some sign of life in the upside-down aircraft. "Susie-Q, it's happened! It's true!" Smith rhymed in a journal written shortly after the July 15, 1942 crash landing of six P-38s and two B-17s. "The lad is climbing out, he's waving at me. Old Mac! I pull 'er up in a roll over him, and circle to approach."

Smith throttled back at 200 feet, cut off the fuel, feathered the props, and slid, wheels up, into a snowy landing. Before sprinting off to join his downed buddies, he logged in details of the flight and landing, shrugged off his parachute, removed his helmet, and threw the keys to the P-38's canopy inside the cockpit.

Over 50 years later, Brad McManus, the pilot of the overturned

COURTESY GREENLAND EXPEDITION SOCIETY

PHOTOGRAPHS © 1992 LOUIS A. SAPIENZA/
GREENLAND EXPEDITION SOCIETY

Members of the Greenland Expedition Society dug in against the island's hostile elements early last May (inset). Somewhere beneath them, buried by 50 years' accumulation of snow and ice, lay this P-38, forced down by weather and photographed just after it slid on its belly to a stop in July 1942.

P-38, looked back on that final detail with amusement. "We all laughed at how he anticipated that somebody might need those keys," McManus says. Foresighted as he was, however, it's doubtful that Harry Smith, who died 10 years ago, could have imagined what those circumstances might be.

Friends for over 20 years, Atlanta businessmen Pat Epps and Richard Taylor have pursued adventure with the spirit of two mischievous boys chasing a girl with pigtails. Epps, the ebullient son of a Georgia aviation pioneer, is the owner of Epps Aviation at Atlanta's DeKalb-Peachtree Airport. Taylor is an architect, pilot, and born storyteller. Every summer, the two would take a small airplane and set off somewhere: sometimes to Mexico, but more often to colder climes.

In 1978, while attending the Experimental Aircraft Association's annual fly-in at Oshkosh, Wisconsin, Epps and Taylor decided, in the reasonable manner of lifelong Southerners, that as long as they were that far north, they may as well try to reach the North Pole. Two years and three attempts later, in Epps' single-engine Beechcraft Bonanza, they made it. Each took turns flying rolls over the magnetic North Pole—one rolling the pole, the other unrolling it, as they like to joke.

Their status as Arctic explorers confirmed, they decided to tackle another northerly adventure Epps had casually dismissed a few years earlier. The idea came to Epps via Roy Degan, an airline pilot based in Atlanta, who'd heard an incredible story from a man who'd flown P-38s in World War II.

The former Army Air Forces pilot, Carl Rudder, had taken part in Operation Bolero, a mission to ferry fighter planes across the north Atlantic to England. Bolero's first flight—led by Paul Tibbets, who later gained fame as pilot of the airplane that dropped the first atomic bomb on Japan—successfully completed the journey. The second—Carl Rudder's—didn't.

Rudder's flight of six Lockheed P-38F Lightning fighters and two Boeing B-17E Flying Fortress bombers ran into bad weather on the third leg of the trip and turned back outside Iceland. But their intended landing site in Greenland was closed and, low on fuel and disoriented in the storm, they couldn't make it to another. The pilots decided to attempt to land on the ice cap, with P-38 pilot Brad McManus, the lowest on fuel, going first.

With the help of electrical generators and a boiler, the cone-shaped Super Gopher tunneled to the airplane.

Pat Epps and Richard Taylor were triumphant last summer after an 11-year, $2 million recovery operation.

Thinking the ice looked flat and firm, McManus went in with his landing gear down. "If I'd been a little more mature and older, I'd probably have said, 'Gee, this is silly to try to save this airplane. Let's just get it down and get out of it alive,' " he says today. "But I did try to save the plane, feeling that if we could get in with our wheels down, we could fly them out."

For a moment it looked as if he'd made it, but then the nose wheel collapsed and the airplane flipped over. The remaining P-38s all landed with their wheels retracted. The B-17s stayed up for another hour or so, sending out S.O.S. signals before they too bellied onto the harsh and desolate site.

For nine days, the 25 men on the flight huddled inside the two B-17s, where they lived, all things considered, in relative comfort. There was little concern about rescue—supplies had been dropped on the third day, and word came that a rescue team was on its way. Men from a special Army Air Forces unit driving a dogsled finally arrived on July 24 to lead the downed crew on an arduous 10-mile march to the southeast coast of Greenland, where a Coast Guard cutter would be waiting.

"There were very mixed feelings at that time," McManus recalls. "There's a bonding that occurs between a young pilot and his own plane, and when you left you were saying goodbye to it in a sense, and that was a very sentimental moment. On the other hand, we were being rescued and we were getting out alive, with no injuries or deaths, and on that note it was kind of a joyful moment that we were finally going to get off the ice cap."

The eight warplanes sitting behind them on the vast sheet of ice would be largely forgotten amid the greater drama of the war—except by the men who flew them.

When Carl Rudder told his story to Roy Degan some 35 years later, Degan became intrigued by the prospect of attempting to reclaim the warbirds from the ice. In 1978 he and a partner asked Pat Epps about using his facility to restore them. They later secured salvage rights to the aircraft.

"I told him it's not my game," Epps says. "I'm into Learjets and Bonanzas and these other things, and I'm not interested in these warplanes at all." But time and experience have a way of changing one's mind—that and in this case a chance encounter Epps had with a wealthy aviator who mentioned that he'd like to buy a P-38. Suddenly the idea seemed worth a closer look. In 1980 Epps and Taylor decided that their next adventure would be to the Greenland ice cap.

"Our thoughts were that the tails would be sticking out of the snow," Taylor says with a grin. "We'd sweep snow off the wings and shovel them out a little bit, crank the planes up, and fly them home. Of course, it didn't happen."

The name "Greenland" is a misnomer if ever there was one. Legend has it that Eric the Red, who discovered it around A.D. 900, gave it the misleading name in order to lure Norwegian and Icelandic settlers to its rocky shores. A protectorate of the Kingdom of Denmark, the island resembles an ice-filled bowl. Over the years, the massive ice cap—10,000 feet deep in places and covering almost seven-eighths of Greenland's surface—has pushed the center of the island below sea level. There the constant snows melt or are compressed into sheets of ice that move steadily outward toward the island's mountainous fringe.

This past July 15, fifty years to the day after his crash landing, Brad McManus found himself standing once again on the ice cap. "I must say, it hadn't changed a bit. It was the same exactly as it was when we were there," he says.

Richard Taylor echoes this observation: "It's totally featureless. It doesn't

WEB BRYANT

Cold Mining

Using a steam probe, an eight-foot-long steel rod trailing 300 feet of steel-reinforced rubber hose, the team located the airplane. They ran 264 feet of one-inch steel pipe down the hole made by the probe and erected an I-beam truss on the surface above. From the truss, a cone-shaped heater with a hole in the center—the Super Gopher—was lowered by an electric winch at the rate of two to four feet per hour. Guided by the pipe, it melted a shaft four feet in diameter. A bilge pump removed the meltwater.

Using a hot-water cannon, the crew carved out a 50-foot-wide cavern around the P-38, which they took apart and sent piece by piece to the surface. They had to sink five shafts to excavate a hole wide enough to lift the last piece of the airplane, the 17-foot-long, three-ton center section. It came up on August 1, 1992, three months after the expedition had begun.

Each expedition member braved The Hole, a 264-foot shaft leading to the P-38.

change." But when Taylor and Epps formed the Greenland Expedition Society in 1981 and traveled that year to the coordinates the B-17 crew members had recorded, they discovered change *did* come to the ice cap. The airplanes abandoned there 39 years earlier were nowhere in sight.

In retrospect, it seems obvious that the airplanes would be buried under a good deal of ice. But no one was prepared for how much. "That year the tail wasn't sticking out, so they were ten feet under," Pat Epps says, recalling the team's confidence. But they didn't find them on their second visit to Greenland later that year, or their third, or their fourth.

In the meantime, however, the Danish government had granted the Greenland Expedition Society exclusive salvage rights to the airplanes; Roy Degan and his partner had allowed theirs to expire, concluding that the warbirds were irretrievably lost.

Still, Epps, Taylor, and an ever-growing group of volunteers remained undeterred. They continued to research the problem, and in 1988 arrived on the ice cap armed with two different sophisticated sub-surface radar systems and crews to operate them.

Within days, the radar teams had pinpointed the exact location of all eight airplanes. And it immediately became obvious why they hadn't been located earlier. The shifting ice had carried the airplanes about two miles from their original location. And a high-pressure steam probe revealed that they lay beneath 264 feet of solid ice.

Working 10-hour shifts underground gave the rescuers a healthy appetite, usually satisfied by chili or pasta.

To supply water for the Gopher and steam probe, the team melted the endless supplies of Greenland ice.

Roy Shoffner had followed the society's adventures from afar, and he became intrigued by the engineering problem of salvaging an airplane from beneath all that ice. It became his favorite topic of conversation among friends and business associates. "Someone would come by and I'd say, 'All right, how would you get that airplane out?' And I'd get their views." Word got back to the society that he was interested, and eventually Shoffner agreed to sponsor a 1992 expedition and accompany expedition members to the ice cap.

Shoffner is typical of the type of individual the society's efforts have attracted: he's a long-time pilot, having flown in the service, in business, and for pleasure. And he's a wealthy man—a retired manufacturer of plastic pipe—with the resources to live what many other people can only dream. Equally important, he's an inventive thinker with an adventurous streak.

Some of the society's greatest technological innovations came not from experts in Arctic airplane reclamation—if there is such a thing—but from the

eclectic group of investors and volunteers Epps and Taylor assembled. Don Brooks, owner of a chain of auto part shops and an air compressor company, as well as the expedition's trusty DC-3, developed a concept for melting a four-foot-wide shaft in the ice. His company built the original Thermal Meltdown Generator—dubbed the Gopher. The 550-pound cone—it looks something like the nosecone of a missile—is wrapped with copper tubing, through which hot liquid circulates. Another expedition member, Bobbie Bailey, owner of a compressor re-manufacturing factory, designed and fabricated an improved version of the Gopher, known as the Super Gopher. She was also the designer of a coring device that, during a 1989 expedition, reached down through the ice and retrieved physical proof that the airplanes were there—a necessary condition for retaining the society's salvage rights.

Pat Epps remembers this as one of the most exciting moments of the expeditions. Previously, the only proof that they'd actually found the airplanes were blips on a radar. Then they sent the coring device tunneling down to where the B-17 "Big Stoop" was believed to lie. "The tubing came up," Epps recalls, his voice still reflecting the awe of the moment. "It wasn't a beer can. Aircraft tubing. The second piece that came up was a piece of skin, a piece of metal—olive-drab metal."

It wasn't until the following year that the Super Gopher actually tunneled its way down to Big Stoop. And that day, the expedition met one of its biggest disappointments. The team discovered that the B-17 had been badly crushed by the weight of the ice above it.

"Now, if that doesn't give you license to quit, there's nothing in the world," Richard Taylor says. "Except we thought, *There are eight airplanes there. We probably hit the bad one.* We talked ourselves into it: We hit the bad one."

Reasoning that the smaller, more sturdily built P-38s would be in better condition, the team members set the sights of their next expedition on Harry Smith's Lightning, the only one shown in 1942 photographs to have survived with its propellers both intact and unbent, probably because Smith had feathered them before landing.

Unfortunately, the society, which had spent about $1.5 million to get to that point, didn't have enough money for a return trip to Greenland. The next year came and went with no expedition at all. Then Roy Shoffner came along with the necessary $500,000 for the 1992 ex-

Test-firing the probe convinced the crew that the steam-spraying device could melt a path for the Gopher.

Trapped inside the ice cave, the P-38 looked helpless despite its fearsome weapons.

The team found Harry Smith's helmet in the cockpit where he had tossed it 50 years ago (inset).

pedition. It seemed a good omen that the trip would put them on the ice cap at the exact 50-year anniversary of the crash landing.

When expedition members recall their work to liberate the P-38 from the clutches of the ice, they talk mainly about two things. They talk about the incredible kick of seeing an 11-year effort finally pay off. And they talk about The Hole, the shaft in the ice through which the adventurers descended and pieces of airplane rose (see "Cold Mining," p. 31).

Imagine dangling inside an icy tunnel so narrow you can't stretch out your arms. The trip down to the airplane takes 20 minutes. You hear the clanking of the chain hoist and watch the opening at the top of The Hole get smaller and smaller until you can't see it at all. When you look below, the tunnel seems endless. And when you look straight ahead you see bands of clear blue ice representing year after year of Arctic winters and summers. It was a test of nerve all at the camp faced, and all passed—though not, understandably, without initial hesitation.

"I thought about that for a year. Sort of mental preparation," Richard Taylor says. "I'd be in an office building in downtown Atlanta. I'd go put my nose up to the glass and I'd look down and you're on the 25th floor and you see a manhole cover from a sewer. Well, that's the dimension: you think, *I'm going down a tube that wide, 25 stories deep.* I had to be scared to death. Ain't no question. But when the moment comes, for whatever reason it's not there. You get in there. You know you've got something to do. You know you've got to go."

The atmosphere inside Pat Epps' aircraft maintenance hangar in Atlanta is giddy this balmy autumn night. There's an impromptu party, and the guest of honor is Harry Smith's P-38. Bathed in greenish light, the components of the still-disassembled aircraft lie in rough approximation of where they should be—though the wings are upside down and the large center section is being placed aboard a ship in Denmark. The airplane serves as the backdrop for a round of speech-making, and each speaker assumes a casually heroic pose—

By July the winches were hoisting the aircraft's larger parts; above, workers receive the horizontal stabilizer.

On July 5, the left engine saw daylight. The society is hoping to refurbish both of the Allison V-1710s.

gesticulating with one arm, resting the other elbow on the P-38's horizontal stabilizer. The chunk of old metal rocks precariously aboard its sawhorse perch.

Epps and company have been assured by experts that the aircraft is restorable, and to a novice's eyes, it does look good. The canopy was crushed by the ice, and in places the aircraft's skin shows evidence of having borne tremendous weight. But as Roy Shoffner, who will be funding the restoration, points out, "It's got all the parts. That's what makes it so nice. If you want to restore Grandfather's old Model T that's in the barn, it's hard to do. But this one was only two months old when it was put on the ice and all the pieces were there."

Pat Epps interrupts: "Roy, I put you on the spot because I told everybody

it's going to be flying at Oshkosh two years from now."

But Shoffner quickly responds, "Oh that's easy. Yeah, we'll do that."

The future of the Greenland Expedition Society seems less certain. The society doesn't yet have funding for an-

other expedition, and Epps is anxious to relinquish his position as society president. "I've been gone too long, neglecting my business too much," he says. "I need to turn to that."

At this point the society and its backers have spent some $2 million, and the restoration of the P-38 should cost another $500,000, so perhaps it's wishful thinking when Epps estimates what the airplane will bring. "I think with the story and everything, it must be a $3 million plane," he says. Bruce Goessling, an aircraft dealer in Chino, California, who's restored two P-38s, places the value of a flying P-38 at $750,000 to $1 million. But he acknowledges that the society might be able to make much more if they reach the right group of investors.

In an effort to raise the airplane's profile, Epps speculates that the society will fly the airplane around a little before auctioning it, including making its promised appearance at Oshkosh in 1994. Portions of the aircraft, as much as could be fit aboard the expedition's DC-3, already drew large crowds of admirers when they appeared at Oshkosh last summer.

Earl Toole, who believes himself to be the only living member of the 1942 rescue party, is in Epps' hangar tonight. Toole has made something of a full-time hobby of documenting the history of the rescue. For this gathering, he has brought a diorama he made: styrofoam icebergs, tiny B-17s and P-38s all correctly arrayed, and tinier figures, accompanied by a dogsled, trekking toward a boat on the coast. At Oshkosh last summer, "people would come up to me, their faces all lit up, and ask, 'Were you one of the pilots?' When I told them no, they'd just say 'Oh' and walk away," he says in good-natured resignation.

None of those pilots is able to be in Atlanta tonight. But it's hard to look at the P-38 without feeling the presence of at least one of them. As Don Brooks and the expedition's chief engineer, Neil Estes, reverently walk around their find, Brooks points to one of the tail booms, where two Lockheed workers signed their names when the aircraft was being assembled. Then he lifts a nearby hatch, revealing the airplane's Identification Friend or Foe transmitter, which the youthful Harry Smith shot full of holes with his .45-caliber pistol before abandoning the P-38. "He definitely left the aircraft with a thought of recovery," Estes is quick to point out. "It took a while," he adds with pride, "but here we are. We've got it." →

Neil Estes watched the DC-3 depart for a Greenland airstrip, ferrying pieces of the P-38 on the first leg of their trip to Georgia.

ASTRONOMY'S
MOST WANTED

SECOND IN A SERIES

LET THERE BE LIGHT

How do cold, dark clouds of gas and dust give rise to the nuclear fires that brighten the universe?

by Andrew Chaikin

Karen Strom is just where she wants to be, in front of her computer at the University of Massachusetts in Amherst. A gloomy, mid-summer rain envelops the day, in striking contrast to the photographs that decorate her office: images of the American southwest in which the sky is clear and seemingly limitless. Strom has grudgingly learned to put up with New England weather, and in any event, these days she spends far less time looking at the sky than she does studying her computer screen. A bizarre, brightly colored wooden carving with wings, horns, and a dragon's face sits atop her terminal—alongside a small menagerie of creatures and a tiny rubber taco—to ward off software bugs. It is here, not at a mountaintop observatory, that Strom hopes to solve one of the oldest mysteries in astronomy: How do stars come into existence?

On the screen, Strom studies an infrared image of a group of stars in the constellation Orion. In visible light many of these stars can't be seen, for they are buried deep within a cloud of interstellar gas and dust called L1641. But in this image the stars' infrared emissions cut right through the obscuring matter, revealing that L1641 is a place where stars are forming in numbers. Displayed as a negative image for greater clarity, the stars look like grains of pepper sprinkled on a white tablecloth. Here and there, dark smudges reveal the light from stars hidden so deeply that they appear only as diffuse glows, like headlights shining through fog. For most of the last seven years, Strom has led an all-out assault on L1641, which, at some 1,600 light-years away, is the nearest stellar nursery to Earth.

"I'm working on little groups of stars within the cloud now," she says, "because I think they're the seeds.... Star formation really goes on there, and the stars slowly escape from there and populate the rest of the cloud." We see these groups of stars, says Strom, during the window in time when they are old enough to have burned off some of their placental gas but are still clinging to one another in the place where they were born.

Scattered around Strom are more photographs, as well as graphs, maps, and stacks of research papers and files. Even the computer screen is divided into several windows, displaying not only the infrared image but numerical data on each star's location and brightness. This is just the way Strom prefers it.

"I feel that I have to surround myself with the data, become entirely immersed within it, in order to have a real feeling for where the data is forcing me to go," she says. If you

ART BY ANDREAS NOTTEBOHM

ask her where that is. Strom will talk with considerable intensity about mass distributions and luminosity functions. Pressed for a simpler explanation, she says, "I want to know how stars form."

She and her husband Steve, whose office is down the hall, are among the most experienced of a group of astronomers who want to answer this question. And the extraordinary pace of advances in the last 20 years has made them better equipped than ever to find out. Thanks to sophisticated software packages, Karen Strom's computer will compile statistics on hundreds of stars and produce stacks of plots while she is out having lunch. "Can you imagine," she says, "when we were first getting this data, we had to sit and make plots by hand?"

PAINTING BY ROB WOOD

Twenty years ago, the study of star formation was a quiet backwater of astronomy. Since the late 1940s the field had been dominated by one researcher, George Herbig of California's Lick Observatory. Astronomers had already identified a variety of adult stars, including massive blue stars, which burn themselves out in a few million years, as well as numerous run-of-the-mill stars like the sun, far smaller and dimmer and a thousand times longer-lived. Using a technique called spectroscopy, in which a star's light is broken up into colors, recorded on film, and then analyzed, astronomers had learned much about the life cycles of adult stars. But stellar birth was still a mystery.

Working alone, pushing his relatively crude instruments to the limit, Herbig painstakingly searched for stars in the act of being born. What he found were sun-like stars a million years old, mere toddlers in terms of stellar lifetime. (Our sun, in comparison, is 4.5 billion years old and has not quite entered middle age.) In the years that followed, Herbig coaxed more details from the dim light of these so-called T-Tauri stars. Today Steve Strom calls Herbig's efforts heroic. "The observations were incredibly hard," he says. "I mean, the exposure times must have been hours per star." Herbig's impact was so far-reaching that Strom credits him with starting the field of star formation. "I've always looked up to him," says Strom. "I still do."

But the secrets of star formation were not to be found with the T-Tauri stars. Herbig knew that hidden somewhere within the dark interstellar clouds were even younger stars still in their infancy, or even stellar embryos. He also knew that those cocoons of gas and dust could never be penetrated by optical telescopes. By the early 1970s a new technology had appeared—the infrared detector—that could pierce the veil. But Herbig never made the transition. Nor did he seek out collaborators with infrared expertise. To do so, Steve Strom believes, would have violated what Herbig held dear (Herbig declined to be interviewed).

CHRISTOPHER SPRINGMANN

"He really felt, as do many older astronomers, that you have to learn an instrument very well, and that the art of observing was a crucial part of your makeup as a scientist and your competence as a scientist," says Strom. "George was perfectly capable of coming over to Kitt Peak and using the

RICHARD NOWITZ

Frank Shu (opposite, bottom) has strived to develop a unified picture of star formation. Shu's hypotheses are shaped by the observations of such scientists as Elizabeth Lada and her older brother Charles (above).

Scientists believe star formation is a five-stage process (opposite, top to bottom): 1. A swirling core of gas and dust begins to collapse under its own gravity. 2. The rapidly spinning material forms a dense knot at the center, which sucks in even more matter, creating a disk around the knot. 3. As the stellar embryo develops a strong magnetic field, gas is blown outward from the stellar poles at high velocities. 4 & 5. The bipolar outflow of gas blasts away the remaining envelope of gas and dust, revealing an infant star.

infrared detector. Something in him said, 'I can't be an expert on this; therefore I won't do it.'

"I've talked to many people just five to ten years my senior," says Strom, "and they're appalled that I'll go to a telescope and not quite understand the inner workings of [its] computer, but I'm still going to use it. Given the sociology of the age when George was learning, in some sense it had to offend him deeply."

And so the star formation torch was passed to a new generation of astronomers, including Steve and Karen Strom. The couple had met the first day of their freshman year at college; he was a Harvard astronomy student, she a math major at the Massachusetts Institute of Technology. They were married a year later. Says Karen, "We've been working together ever since."

One night in April 1972, they trained a simple infrared photometer on an interstellar cloud in the constellation Ophiuchus. Every now and then, as the telescope scanned the dark cloud, the signal on their chart recorders jumped. They knew immediately what they had found, but they couldn't be certain until late in the following day, after they had plotted the data by hand. They had discovered a cluster of stars hidden within the cloud—one of the first confirmations that interstellar clouds really did harbor stellar nurseries. For the rest of the decade, the Stroms and other astronomers patiently probed interstellar clouds, striving to glean more information about the stars forming within.

At the same time, other astronomers were using another emerging technology, radio telescopes, to study the clouds themselves. Charles Lada, an astronomer at the Harvard-Smithsonian Center for Astrophysics in Massachusetts, remembers, "We started mapping these things and realized they were huge—much bigger than anything that could have been imagined." Some were 300 light-years across, 75 times the distance from the sun to its closest stellar neighbor. In fact, they were the largest objects yet found in the galaxy, and among the coldest in the universe. In the dark reaches of these so-called giant molecular clouds, temperatures hover as low as –400 degrees Fahrenheit. And although they are incredibly rarefied, with densities a hundred trillion times less than that of air, they contain enough material to form hundreds of thousands or even millions of stars like the sun.

ART BY ANDREAS NOTTEBOHM

Whatever theory was devised to explain star formation, it would have to figure out how such tenuous stuff could be squeezed into a ball so dense that within its core the natural forces of repulsion between protons are overcome, causing hydrogen to be fused into helium and igniting the nuclear fires that light the universe. Asks Lada: "How does nature know how to do that?"

By the late 1970s, Frank Shu, a theoretical astrophysicist at the University of California at Berkeley, was devoting his energies to answering that question. The basic picture seemed straightforward: Within the molecular cloud a small pocket of gas and dust, called a core, reaches a critical density and begins to collapse under its own gravity. As the core shrinks, a dense knot develops at the center. Collapsing from the inside out, the knot grows increasingly dense and attracts more matter. As it does so, it spins more rapidly, like a figure skater pulling in her arms. After enough mass has accumulated, centrifugal force flattens the incoming gas into a disk that girdles the embryonic star's equator. Within the disk, matter spirals inward until it reaches the surface of the ball. Eventually, temperatures and pressures at the center of the ball become high enough to trigger the fires of nuclear fusion. At that moment, it's safe to say, a star is born.

"Stars are what they are because they have a say in their destiny."

But when Shu tried to simulate this scenario on a computer, the star never stopped growing; it continued to acquire matter from the cloud indefinitely. Shu and his graduate students tinkered with the ingredients of his mathematical recipe, but not until the early 1980s did Shu hit on a solution—thanks to a stunning new discovery by astronomers Ron Snell, Robert Loren, and Richard Plambeck.

Other astronomers had observed jets of cold gas streaming through molecular clouds at extraordinary speeds, up to 200,000 mph. Snell and his colleagues discovered that these violent winds occur in pairs that are pointed in opposite directions, leading some astronomers to deduce that they emanate from the polar regions of unseen young stars. By 1984, Charles Lada and colleague John Bally had surveyed scores of clouds and found the winds to be so common that it became clear that all stars have them during their early lives.

But what causes them? That is controversial, but Shu believes the winds come about as the new star develops a strong magnetic field. Due to the star's rapid rotation, Shu proposes, the magnetic field acts like the blades of a giant high-speed fan, forcing gas outward at high velocities from the stellar poles. Furthermore, the winds would be powerful enough to halt the growth process by holding back much of the gas trying to fall onto the new star. And they would even keep the star from spinning too fast and breaking apart. To Shu, the winds were the missing piece in the puzzle.

"The most fundamental thing about a star," he says, "is its mass. In some sense, people have dodged the issue prior to this. They've always said, 'The [star's] mass is the mass of the cloud that it collapsed from.' That's just output equals input." On the other hand, says Shu, if his theory is correct, "then there's a much richer answer. Stars are what they are because they have a say in their destiny."

Elizabeth Lada can remember when her older brother Charles, then a high school senior in Webster, Massachusetts, would take her out to show her the heavens with his new telescope. The memories are hazy—she was only five—but those sessions helped spark a lifelong interest in science. Charles held a special place in her family as the first to go to college, and by the time Elizabeth was in high school in the late 1970s, he had made a name for himself. He'd even been written up in *Time* magazine for his work on star formation.

On occasion Charlie would come to give a lecture to the Webster astronomy club. Sometimes the club even made the hour's drive to Cambridge for the Harvard Observatory's public observing nights. But when people would ask Elizabeth whether she wanted to follow in her brother's footsteps, she would always say no.

RICHARD NOWITZ ©1

Married for 33 years, the Stroms—Steve and Karen—have devoted much of their lives to the field of star formation.

"At that age I had this real independent streak," she says today. "I wanted to be different." Not until her senior year at Yale University in 1983 did Elizabeth take her first astronomy course: she ended up liking it so much that after graduation she spent nine months as a research assistant to a Yale astronomer. By that time she was hooked. "I can remember thinking, *It doesn't matter that Charlie's an astronomer; I'm going to do it.*" To her great surprise, her brother greeted the news with pessimism. "He told me all the terrible things: It was very competitive. The funding is very tough. Graduate school is very hard. There are days where you think, *Forget it, why am I doing this?* But at that point I had already made my decision."

In truth, Charles was thrilled. "I realized for the first time," he recalls, "that there was someone in my family who could understand, have an inkling, what in the heck it is that I do."

Three years later, as a graduate student at the University of Texas, Elizabeth had joined the fold of star formation researchers. She embarked on a survey of giant molecular clouds with the same telescope her brother had used, an instrument sensitive to millimeter-wave radiation, which falls between infrared and radio waves in the electromagnetic spectrum. Despite the very low temperatures found in a molecular cloud, there is still some movement of its molecules, and when they collide, they release energy in millimeter waves.

As Lada began her work in millimeter astronomy, infrared astronomy was undergoing a revolution. In 1983, NASA's Infrared Astronomical Satellite opened a window on the infrared universe: its images revealed that stellar nurseries were sprinkled throughout the sky like glowing embers. Since then, newer and better instruments have offered astronomers the chance to study IRAS' findings in greater detail.

In 1987 Lada heard about a state-of-the-art infrared camera developed by the instrument wizards at Arizona's Kitt Peak National Observatory. In December, she and her thesis advisor, Neal Evans, used the camera, attached to a 50-inch telescope, to look for infant stars in a giant molecular cloud in the constellation Orion. Training the telescope on the cloud, they homed in on a dark cleft within a glowing nebula of gas and dust. When the image appeared on the computer screen, Lada was stunned. The dark cleft had been transformed into a sparkling river of stars.

"It was really one of the most thrilling times I've experienced," she says today, studying the picture. "I'd have to say I got turned on to infrared astronomy after this. Isn't it amazing?" Indeed it is, even to Ian Gatley, one of the astronomers who designed the camera. He says it would have taken Karen and Steve Strom a few centuries to obtain the same data with the photometer they used back in 1972. In a comment that belies his own intensive efforts, Gatley says, "The technology gets so much better so fast it almost seems like magic."

Lada, Evans, Gatley, and Kitt Peak astronomer Darren DePoy went on to produce the first systematic infrared survey of the entire northern Orion cloud, and when they finished they made a surprising discovery. Stars weren't forming randomly throughout the cloud as they had expected.

Instead they were forming in small, densely populated clusters, each containing up to several hundred suns. From that finding, Lada proposed that many if not most stars are born not as only children but in huge litters.

Even more intriguing is that star formation is confined to a few small areas in the cloud. Lada's own study of the millimeter emissions of gas molecules within the cloud indicates that the gas around young stars is very dense, relatively speaking. But no stars have formed in other parts of the cloud where the gas is equally dense. To understand why, Lada—now a researcher at the Harvard-Smithsonian Center for Astrophysics—has begun a more detailed study not only of the stars but of the interstellar gas around them. She is asking the same questions that a biologist might: What causes an interstellar cloud to give birth? Why does one cloud spawn massive giants and another give rise to stars the size of the sun?

Says Suzan Edwards, an astronomer at Smith College in Massachusetts: "Every place you go, no matter where you go, in our galaxy, in another galaxy, you keep seeing the same thing. Low-mass stars form all over the place. High-mass stars hardly form at all. That's telling us something. There's something magic about the distribution of stellar masses that we don't know yet. It remains magic until we understand the physics."

For now, the answers to questions like these must come from scientists who straddle theory and observation, like Harvard-Smithsonian's Phil Myers. He believes that two factors determine what kind of stars form in an interstellar cloud: the density of the cloud and the density of magnetic energy within the cloud. Magnetic energy, he says, acts like a spring that resists the force of gravity. A core can amass only so much matter before its own gravity overcomes its internal magnetic spring and it begins to collapse. The more highly magnetized it is, the more massive it can become before that happens. When the core finally does collapse, gas streams inward at a higher rate than it does in less dense cores. This faster assembly, says Myers, is the key to forming massive stars. In short, the more magnetized and dense a cloud core is, the more massive the stars it can spawn.

What if most stars form in crowded nurseries, as Elizabeth Lada suggests, instead of as the lone objects simulated in Frank Shu's computer? Karen and Steve Strom believe the forming stars would interact with one another, either gravitationally or by brushing against one another in the early stages when their atmospheres are distended. No one knows how that would alter Shu's scenario, but Shu is confident.

"I think we have basically got it," he says. "Yes, multiple cores in a dense environment will cause modifications, but they won't be the spectacular modifications that are comparable, for example, to when we discovered bipolar flows."

"He can afford to be confident," says Charles Lada. "He's the only one who's got a unified picture." But until Shu's scenario is confirmed by observers, it's just a working hypothesis. And the observers have a long way to go.

"Despite the great success we've had in the last ten years," says Lada, "all the basic, fundamental questions are still unresolved. We haven't actually detected a star in the process of formation. We don't understand anything about molecular clouds and how they evolve. Half the stars [we see] are binaries, and nobody has a clue how that happens." Even bipo-

ART BY ANDREAS NOTTEBOHM

lar winds—the key to Shu's theory—are still unexplained.

Not that these uncertainties bother Lada. He says of Shu's scenario, "Even if it's wrong, that doesn't diminish Frank's stature. It's challenged us. It drives our thinking."

Even as Lada spoke, new results were promising to confirm one of Shu's ideas. University of Texas astronomer Shudong Zhou reported what may be the first direct observation of a small interstellar cloud in the process of collapse. Furthermore, it appears to be condensing from the inside out, just as Shu predicted. "As far as I can see," says Zhou, "this is the first evidence where it all hangs together, observation and theory."

Lada was stunned. The dark cleft had been transformed into a sparkling river of stars.

Back in Amherst, under the rubber taco, Steve Strom studies an image of a small grouping of infant stars deep inside L1641. He points out some of the individual members: a star with twice the sun's mass, one with three and a half solar masses, and a three-solar-mass star. Radio data shows that these stars are accompanied by violent bipolar flows. "I think this is really neat," Strom enthuses. "This has to be a region where star formation was orchestrated to start no more than a few hundred thousand years ago."

What the image doesn't show—because no existing telescope is powerful enough—are the disks that surround each of these stars. Strom knows the disks are there because the stars' spectra show an excess of infrared radiation—the excess being emitted by the disks themselves. And it's the presence of these disks that tells Strom the stars are very young. What he wants to understand is how gas is transported through the disk onto the surface of the growing star. "If I can't understand that," he says, "I can't understand how to build a star." He believes the disk plays a key role in keeping the star from spinning too fast as it collects more material. And there is another reason the disks are important: ultimately, they are thought to give rise to solar systems like our own.

Ask Strom what he'd most like to see a picture of and he says, "I want to see the disks." Sometime in the next decade or so, he may get his wish, thanks to instruments now on the drawing board for both Earth- and space-based observatories. In particular, a technique called interferometry, in which several small telescopes are combined to give the resolving power of one very large instrument, will be available for both radio and infrared observations. When that happens, Karen Strom and Elizabeth Lada will be able to probe the structure of interstellar clouds in detail, and Steve Strom will be able to see his disks.

Even after such advancements, however, astronomers don't expect the mystery of stellar birth to be completely solved. Steve Strom says he will be happy if at the turn of the century he can look back and see some progress in answering the major questions. "I really believe we're putting together a comprehensive picture of star and planet formation in a broad outline," he says. "I don't think we'll ever have all the details right." Strom has learned to be comfortable with uncertainty. "Astronomers like George Herbig are classicists who believe in ultimate truth," he says. "That sense of classical perfection is part of their upbringing. It isn't part of mine."

For now, star formation researchers are engaged in the kind of detective work that is an astronomer's stock in trade. Unlike the case with many other fields in astronomy, the potential for star formation to be revolutionized by a single discovery is fading. It's time for the pick-and-shovel work, the relatively unexciting statistical studies that will bring us to the next level of understanding. Over the next several years astronomers will have to do for young stars what 40 years ago they did for adult ones: develop a scheme for classifying proto-stars, figure out how old and how massive they are, then piece together a picture of their evolution. It won't be easy. The clues will be subtle, perhaps only a minor difference in an infrared spectrum. Astronomers will need all the ingenuity they can muster. But no one doubts it will be worth the effort.

Ninety Years On

Edward W. Stimpson, President, General Aviation Manufacturers Association

America's general aviation industry has been battered. But it's not asking for a handout; it's asking for an even chance.

The American aviation industry has led the world since that first flight at Kill Devil Hills in 1903. We have produced the vast majority of the world's aircraft and turned out thousands of pilots, each one an average American no different from you or me. The nation's love affair with aviation has continued through wars, economic downturns, and the technology's evolution from the days of the open cockpit to the ultimate airplane—the space shuttle. During that time, we have come to embrace many of our pilots—from Charles Lindbergh to Chuck Yeager—as national heroes.

In less than a century, the growth of aviation in the United States has been as revolutionary and far-reaching in its impact as almost any other human achievement. Most Americans are proud of that accomplishment and regard it as part of our national heritage.

But at this moment in our history as a nation it is important for us to recall that when the Wright brothers fashioned the first airplane, it was designed to carry a single pilot who was master of his own fate. Of course, in the 90 years since that flight, the airplane has grown and evolved into a family of diverse machines, from supersonic military jets to huge airliners capable of carrying hundreds of passengers. Although we're not always mindful of it, throughout those 90 years light airplanes continued to be manufactured and operated in this country, and today the category now called general aviation (all aircraft except large airliners and military aircraft) outnumbers all others combined. The modern general aviation airplane is faster, smarter, and safer than it has been at any time in its development, and many of today's light airplanes share some of the sophisticated technology used by airliners.

Yet for the first time in our history, American leadership in general aviation is in jeopardy.

In the last ten years, production of small general aviation aircraft has plummeted by more than 90 percent. In the late 1970s, U.S. manufacturers produced more than 18,000 general aviation aircraft a year. This year will be the worst on record since World War II: the United States will produce only about 1,000 airplanes.

Production of single-engine aircraft, the backbone of general aviation in this country, has come to a virtual stop. Cessna has not produced a single-engine aircraft since 1986. Piper, the company that brought the Cub to every country airport in America, is in bankruptcy proceedings. Fifty percent of a highly skilled work force may be lost permanently if we don't turn things around.

A number of factors are bringing the industry to its knees, including the economy, an ample supply of used aircraft—though the fleet is aging alarmingly—and legal issues that center on our product liability laws. In fact, the product liability mess in this country has hit general aviation harder than any other U.S. manufacturing segment. A recent Brookings Institution study of the impact of liability concluded that general aviation was by far the most severely depressed of any industry in the nation. Yet today's general aviation aircraft are the safest ever: in the period since World War II, fatal accidents have declined more than sevenfold. Of those that do occur, 93 percent are due to factors such as pilot error, weather, and maintenance—all beyond the manufacturers' control. Nonetheless, lawsuits aimed at manufacturers are causing many companies to halt production of certain models entirely. The industry has been battered. But it's not asking for a handout; it's asking for an even chance.

We are at a crossroads: America needs a vigorous general aviation industry. According to *Air Transport World* magazine, this country's major and national airline carriers served 468 million travelers during 1990, the largest number in the world.

Why it's important to remember that the Wright Flyer was a light airplane

Regional and specialty airlines handled another 1.2 billion customers. But we seem to have lost sight of our other "air carrier": the general aviation fleet carries 120 million people every year, most of them to small towns and remote areas, where the single-engine airplane can be a lifeline. General aviation airplanes train pilots, provide eye-in-the-sky traffic reports, carry mail, perform medical evacuations (more than 600,000 last year alone), and transport farm families to urban centers for needed services.

But general aviation is more than just manufacturing and employment statistics. In fact, it's not about transportation at all. It's about *flying.*

The United States provides the majority of the world's aircraft in large part because we, its citizens, support our aviation industry and want it to thrive. We support it because we view the role of aviation in our society as an extension of basic democratic principles: each of us shares equal access to our skies. In many areas of the world, governments fear the very notion of allowing any citizen access to the airways, and few nations make it as easy as the United States does to own and operate an airplane.

That doesn't mean that all Americans become pilots and airplane owners. In 1990, only 702,659 pilots were listed in Federal Aviation Administration records—a relatively thin slice of the U.S. population. But the *idea* that we all have equal access to the air is important, because embodied in it is a sense that we are all part owners of our nation's vast aerospace enterprise in all its forms. We invented aviation and brought it to the world; it's important to our future, and evidence of our proprietary stake in the American aerospace industry's future is everywhere. We built the National Air and Space Museum to house the treasure of our creativity, and it's become the most popular museum in the land.

We take as a right the opportunity to become pilots and participate. But when we think of participating, we don't immediately picture an airliner or a supersonic fighter. The beacon of our belief in that right is the light airplane.

And we have certainly not turned away from flying despite the hardship our domestic industry faces; to an increasing degree, though, other nations are supplying the machines. Is it too late to reverse the decline and save our general aviation industry? Not if we act soon. Congress must pass legislation to limit the term of liability for an aircraft's design and manufacture to 15 or 20 years instead of the full life of the airplane. All 50 states have different laws governing product liability, a legal maze that makes it nearly impossible for manufacturers to protect themselves against lawsuits. With the existing legal system, an airplane found safe in one state may be deemed unsafe in another. Tort reform legislation addressing these issues is currently before Congress. And the role of the federal government as the sole arbiter of aircraft design standards must be reestablished. An important milestone was recently passed when the U.S. government filed a brief (*Cleveland* v. *Piper*) supporting the principle of a single federal standard for aircraft design. Unless the federal government prevails, the possibility arises that each of the 50 states will set its own aircraft design standards, making it virtually impossible to manufacture aircraft in this country.

In a very important sense, though, the future of our aerospace industry is in the hands of each and every one of us. Just as we share in our pride of accomplishment, so must we share responsibility for ensuring that the soul of our industry is preserved. As we near the 90th birthday of American aviation, we can't allow ourselves to forget that the emblem of our society's affection for and support of flight is a class of airplanes about the size of the *Flyer.* →

General aviation is more than just manufacturing and employment statistics. It's about flying.

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Another First From Philips

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Fifty years after the Eighth Air Force arrived in Britain, its veterans made another visit. This time England was ready for them.

THE RETURN OF THE MIGHTY

by Stephen Bloomfield

COLOR PHOTOGRAPHS BY PATRICK WARD

When Jim Hower completed his 30th and final mission as a B-17 copilot on March 18, 1945, he just wanted to go home to Kansas and resume his life as a music student. So he left England behind him, taught music for a bit, then got into insurance, prospered, raised a family, and thought very little about the war. "You wanted to get back to living," he says now. "You felt like you lost three years of your life, so to speak. I really didn't want to talk much about it."

But as the years went by, the tug of the past grew stronger. "Finally in December of '90 I was able to get in contact with two members of my crew," Hower says. "One of them, John Kilpack, I found, had kept a log of all of his flying time and all of his missions, and I got to reading that and it read like a best seller." Hower, Kilpack, and another gunner, Dean Sassaman, finally attended a reunion of the 447th Bomb Group in Dayton, Ohio, last year, "and the thing has just grown from that." And on May 29, 1992—a typically damp English day—the three men returned to Rattlesden airfield in Suffolk, where they had been stationed as B-17 crewmen with the U.S. Eighth Air Force.

With them on the airfield were a hundred other members of the 447th Bomb Group. And they were just a fraction of the estimated 15,000 U.S. veterans who returned to England earlier this year to commemorate the 50th anniversary of the Eighth Air Force's arrival in Britain. The brash youngsters of the 1940s were long gone, replaced by gray-haired men in their late 60s and early 70s, some with wives and children. Throughout the counties of East Anglia—Norfolk, Suffolk, Cambridgeshire, and Essex—the villages that had hosted the Amer-

EIGHTH

B-17s of the U.S. Eighth Air Force penetrate into the heart of Germany on a mission to Berlin. A half-century after the Eighth's arrival in Britain, veterans returned to attend a commemorative service at the American Cemetery near Cambridge (inset).

NASM (2)

Many of the airfields built for the Eighth were constructed on farmland (left). They were used by bombers as well as fighters like the P-38 (right).

icans during the war opened their doors again. In all, 50 of the 80 airfields occupied by the American units had some kind of reception planned. Where nothing substantial of the airfields remained, the nearby villages held dances, banquets, or church services to celebrate the Americans' return.

To men like Hower, returning to Britain was a natural response to memories that reunions in the States had stirred up. For many of them, the squadron and group associations they belong to have become an important focus for their lives after retirement. Other men returned for different reasons. For Ed Stern, who arrived in England in 1943 as a 29-year-old administrative officer for the 385th Bomb Group, the return to Britain provided a chance to show the two grown-up children he had brought with him "where all those outlandish stories I had told them really took place."

Most of the veterans returned on tours organized through their associations. Although tight scheduling helped the villages in England organize their events, often two or three years in advance, it did leave some of the visitors frustrated. "The schedule was a little hectic," says Stern. "We had only three hours at the old base out of a nine-day trip. Some of us would have liked a full day to reflect on things."

Hower, Kilpack, and Sassaman wandered around the field at Rattlesden, pointing out the changes 50 years had wrought. "I got a hold of a young English boy over there who had a jeep and I got him to take Kilpack, Sassaman, and me around," Hower recalls. "We spent about an hour and a half riding around the base trying to locate where certain things were." As he climbed the steps to the control tower, now operated by a gliding club, Hower felt a "spooky feeling. I can see in my mind's eye the faces of people that I had forgotten for 50 years," he says.

It was in February 1942, two months after the Pearl Harbor attack, when General Ira Eaker arrived in England to pave the way for the men and machines of the Army's Eighth Air Force. Over the next few months his forces began to gather in England, and by August the Eighth mounted its first all-U.S. strike against occupied Europe. It was a modest beginning for what would eventually become the largest air striking force ever assembled. Most of its airfields were newly built in a surge of construction that at the time was the largest civil engineering project in the United Kingdom. Forty-one of those fields were occupied by the Eighth's heavy bombing groups and 15 by fighter squadrons. More than 350,000 airmen of the Eighth were stationed in Britain. By the time the Americans left, 26,000 of them had died and 18,000 had been captured, and 9,000 of their aircraft had been lost. An airman flying with the Eighth Air Force had had only a one-in-three chance of surviving his tour of duty.

For both the Britons and the Americans, the "Friendly Invasion" was a learning experience. The arrival of so many Yanks was a shock to many Britons, some of whom complained that the Americans were "overpaid, oversexed, and over here." For the Americans, many of them young men who had never been far from home before, life in England was disorienting. "In the '30s, most English people knew the Americans only from the cinema screen and vice versa," says Roger Freeman, a British historian and authority on the

The 75 members of the 398th Bomb Group who returned to Britain in June attended a service honoring compatriots who had died in the war (below). It was one of many such gatherings held in 1992 (opposite, inset).

Eighth Air Force. "The Americans were thought of as brash and boastful with too much money. But what did that matter to them when they might not be around tomorrow? But I think the situation changed as individuals got to know each other."

When Jim Hower arrived in England in 1944, shortly after D-Day, his first impressions were not very favorable. "It was a godforsaken country," he recalls now. "We landed in Liverpool on a gray drizzly day. I remember the sea gulls wheeling overhead and the weather but I have no recollection of Liverpool." Life on the base was no better. "The accommodation was not very good. Poor heating in the barracks; no sanitation in the field, so we had to have what we called the honey bucket trucks. Boy, the smell!"

Robert Kopke, then a 21-year-old radio operator with the B-17s of the 95th Bomb Group, which was stationed at Horham, had a better first impression. "I fell in love with the country from the word go," he says. He quickly developed a taste for warm beer, fish and chips, and darts. He bought a bicycle and spent much of his off-duty time touring the countryside. "I guess that a lot of the reticence of the British had disappeared by the time I arrived as a replacement crewman in '44. And a lot of the brashness of the Yanks had been worn off too. And I'm sorry to say that we were brash and noisy at first. But by 1944 the welcome mat was out. We were treated so well wherever we went."

Like Kopke, P-51 Mustang pilot William Bruce Spengler developed a knack for darts. His squadron, based at Duxford airfield, made evening "fighter sweeps" to the Red Lion pub in nearby Whittlesford. The regulars, who had grown used to thrashing the Yanks at darts, began losing more and more frequently. The atmosphere chilled slightly. To defuse any potential animosity, the Americans would purchase large pitchers of beer for all—a purchase that eventually became something of a challenge in itself.

Many of the bomber crews, flying long hours on oxygen high above enemy territory, subjected to overwhelming noise and the gnawing fear of being shot out of the thin, cold air, had little time for darts. Time not spent in

an airplane was spent in slumber. The ground crews, working to arm and prepare aircraft for missions, often worked 16- to 18-hour days. Some men never left their base during their entire stay.

"We were too young and stupid to know that what we were going on wasn't just a great adventure," says Ed Stern, whose 385th Bomb Group was based at Great Ashfield in Suffolk. Like many Americans, Stern came to miss the little things, like the taste of cold milk (English non-pasteurized milk was forbidden to the servicemen, who made do with the powdered variety). He had to learn to drink coffee instead. Still, the food that Americans ate on their bases was superior to that of the British, whose supplies were heavily rationed. Stern remembers that what passed for hamburgers in England "tasted like they had been made with sawdust."

Some Americans tried to create as much of a home life as they could. When poor weather precluded flying, Stern and others would go into the nearby village and visit a family, bringing fruit juice or some other rare commodity with them. When possible they would treat the children to gum and candy from their rations. "Got any gum, chum?" became a standard greeting between English children and American servicemen. Often aircrew returning from missions would take their unfinished rations and lob them from their waist gun ports to the children waiting at the perimeter fence below.

Clay Snedigger was the intelligence officer for the 351st Bomb Group, which was based at Polebrook in Cambridgeshire for a time in 1943. He remembers American commanders cultivating British friendship by encouraging base parties for the local children. "It was a way of getting over the initial reaction of shock on both sides," he says. "For the British because of the sudden arrival of lots of Americans. For the Americans because of being away from home in a strange damp climate away from the luxuries they had previously taken for granted. After we got to know the children the relationship developed very fast."

John Alston was one of those children. He was only eight when he went to a base party, but he still remembers the hot doughnuts he ate there. "But the bananas, which I had never tasted before and which I had been told so much about, disappointed me," he says.

During the war, Alston's parents had opened their Lavenham home to the Americans of the 487th Bomb Group, whose base had been built on the Alstons' farmland. He remembers evenings when the base commander would drop in to talk with his parents—perhaps, as Alston now realizes, to unburden himself to two adults not connected with his everyday life. He remembers the noise of B-24s warming their engines each morning at 5 a.m. "But what I remember most of all is the jeep rides that I got back from the base if I accidentally on purpose happened to stray on to the field," he says. "My parents would get very cross but to a five-year-old boy it was worth it, especially if they took me to the guard room and I got told off by an MP sergeant!"

The music of the big band era provided much of the soundtrack for the return, proving that even 50 years later "it don't mean a thing if it ain't got that swing."

COURTESY JOHN ALSTON COLLECTION

Lavenham today is still a small Suffolk village. Its winding main street is lined with old half-timbered buildings, all pink or whitewashed, their upper stories often tilted at odd angles. When the 487th Bomb Group returned last spring, the town's square was decorated with bunting and intertwined flags and all the shop windows were adorned with mementos from the war years. The town hotel, the Swan, is one of the oldest in the country, dating back to the 14th century. One wall is covered with signatures of the servicemen who had passed through the town during the war. Many of those who returned this summer found their names on that wall.

And at the party Lavenham threw for the 487th, John Alston once again met the man he remembered most from the war years: Mickey Soss, the man who used to lift the barrier gate to allow the children to cross the main runway on their way to school. Soss is now retired and living in New Jersey.

Base parties may have helped win over the locals, but for night life, airmen liked to head into London on three-day passes—"to raise a little hell," as Bruce Spengler puts it. "As an American in London the English women were all over you," remembers Nelzo Cassano, a crew chief with a B-26 Marauder squadron based outside Earls Colne in Essex. "You practically had to fight them off, because all their soldiers were away." American accents, better cut uniforms, and superior spending power proved strong attractions for some of the local women. By the end of the war, 60,000 of them had married Americans. Au-

The American Cemetery ceremony provided an opportunity to remember the dead. A lone B-17 flew overhead, one of the few survivors of the formations that darkened English skies during the war.

thorities on both sides tried to discourage the practice, but some dubious liaisons still slipped by. In June 1943 Norwich's *Eastern Daily Press* reported that a local woman had married an American lieutenant—conveniently forgetting that she already had a British husband serving overseas.

Bill Austin saw the invasion from the other side. The burly Londoner had begun serving in the war by driving trucks full of sand and ballast for the new Essex airfields, then joined the elite Parachute Regiment and saw action all over Europe. He saw some of it closer to home when GIs and British troops met on English training grounds and suppressed enmities occasionally boiled over into brawls. "Most of the time drink was the problem and the rest of the time it was the same things that any 18-year-olds will scrap about—money and women," Austin says.

Austin attended one of the anniversary events, a reception organized by the Essex County Council to welcome back one group of vets—the Marauder Men of the B-26 Historical Society—that had been largely based at Essex airfields. Austin had laughed as he watched the vets jitterbug with some of the English women to the sounds of a dance band. "Look at that," he said. "Fifty years on and they are *still* pinching our women."

Like many of his fellow Englishmen, Sir Ian Jacob was often perplexed by the Americans. A senior staff officer for the Churchill war cabinet, he lived then—as he does now—in the small Suffolk town of Woodbridge, close to a soon-to-be-closed air base. "It seemed to me that the Americans had a continual sort of surprise, as if they had come to a savage country and expected to be attacked by the natives all the time," he says. "I remember local prices going up for some things, so perhaps they were being attacked in a way."

When Jacob attended Mess dinners he was surprised by some of the customs. "I could never get used to eating at six o'clock, which is when they all ate," he says. "And I didn't like drinking cocktails before dinner and in such quantity."

But what troubled Jacob most of all was the fact that there were slot ma-

Many of the Americans brought their wives and families to the wartime sites in England.

chines in the Officers' Mess. "I thought it was totally incongruous—not only that they played with them in the Mess, but that they had used cargo space to bring them across."

To the beleaguered and rationed British, such American excesses were often overwhelming. "I found it difficult to comprehend how they could have so many staff officers," says Jacob. "They would use a colonel to do a job we would ask a secretary to do. But the inestimable thing that they brought with them was the huge fillip they gave us. Without doubt we knew then that the war would be won."

Fighting the war in the air was often a brutal business. To ensure greater accuracy, the American high command had insisted on flying daylight bombing raids, despite arguments from the British, who had been so bloodied on their day raids that they had switched to night. The Americans persevered despite high losses, and with the RAF bombed Europe around the clock.

Cooperation between the two allies could often mean the difference between life and death. Patrick Murphy had been a radio operator on a B-17 based at Horham. Returning from a particularly bloody raid over Bremen, the pilot instructed Murphy to radio ahead that they had dead and wounded on board. German fighters had shot off the bomber's main aerial, so Murphy trailed a wire from the belly of the airplane and—without much hope of success—

Members of the 398th Bomb Group returned to their local pub, just across the street from the group's memorial.

sent his message. "Within 10 minutes the British air-sea rescue people responded, telling me that they had my position and were sending planes out to escort us back," Murphy recalls. "I felt as if I had been knocking on the pearly gates and an angel had come down and said 'Jump on my wing.' "

Many British civilians remember watching huge numbers of aircraft circling in the sky as they made up formations, and the red flares bombers fired when they returned with dead or wounded on board. Sometimes people on the ground would be helpless witnesses to accidents in the sky. Elizabeth Chambers of Eye in Suffolk remembers "the watches still ticking on the wrists of dead crewmen who had been killed when their Liberators collided and landed near where I was bringing the cows in for milking."

Helen Roe, the oldest inhabitant of the Suffolk town of Horham, was hanging her laundry one day when she saw a B-17 and a P-51 Mustang collide, then tumble to the ground. Until then her experience of the Americans' stay had been enjoyable. In fact, she sometimes feels guilty that she enjoyed the war. "There were always dances and parties every month at the base," she says. "I remember Glenn Miller coming to play very well. They would send down big trucks to pick the women up so that we could go along and [they] brought us home by truck too. Always with an MP to check that the GIs hadn't smuggled themselves aboard!

"Some people didn't like [the Americans], of course, thought that they were loud and uncouth. But they were very generous, shared their rations with us, brought us cartons of cigarettes. They used to treat me a bit like a mother figure, I suppose, because I was a bit older."

What Mrs. Roe didn't like was when the crew of Robert Kopke's airplane, *Miss Liberty,* revved the engines on the taxiway next to her washing line, spattering the clothes with oil and mud.

When the men of the Eighth Air Force returned home, they left a big hole in the lives of those who had grown used to their presence. Communities that had swollen to three or four times their peacetime size shrank back to a sort of normality and faced the austerity of Britain's postwar years.

As a boy, Frank Patton lived near the airfield at Eye, which housed the 490th Bomb Group from February 1944 to August 1945. Always a bit of a loner, Frank spent much of his free time at the airfield running errands for the Americans who manned the gun emplacements and serviced the aircraft. When he was the tender age of nine, the Americans taught him how to smoke cigars. Frank brought them fresh eggs and took their washing home to his mother in return for rations.

Today Patton still remembers one gloomy morning in August 1945. The war in Europe had ended, but Patton had continued to cycle up to the field to see his American friends who were still stationed there. On this day he was surprised to pass unchallenged through the perimeter gate. He continued up to the corrugated Nissen huts. After knocking on the first door, he cautiously pushed it open. The building was empty, stripped bare. He tried others; they were all empty, with nothing but debris remaining. The Americans had gone. To Patton it seemed like they had disappeared overnight.

The devastated boy, his world of errands, fat cigars, and friendships shattered, sat down in front of one hut and cried. Nearly 50 years later he still remembers the hurt. "It was the saddest day of my life," he says.

During the war, King George and then-Princess Elizabeth visited the crew of the Memphis Belle. *A look-alike* Belle *was on hand this year.*

NASM (2)

In 1942 only 18 bombers participated in the first all-U.S. raid; by war's end a single mission could include thousands of airplanes.

RATSUHIRO TOKENAGA

GEORGE HALL

A 12-Pack of Pictures

In the colorful world of aero-calendars, the pinup's almost always an airplane.

by George C. Larson

It's that time of year again. As 1993 approaches and last year's package of 12 stunning, full-color, suitable-for-framing photographs comes down off the wall, we bid adieu to January through December 1992 (B-24 Liberator through P-51 Mustang, in the case of Phil Makanna's "Ghosts 1992") and pitch last year's aero-calendar into the environmentally correct recycling bin.

Or will this be the year we finally clip out our favorites and hang them in that forlorn corner of the office that needs something to brighten it up a bit?

These are vintage years for aero-calendars, and the selection for 1993, only six of which are represented here, is as attractive as ever. Five of the six are published by individual photographers, some

"The Cutting Edge" calendar for 1993 leads off with a cover shot by Tokyo-based Katsuhiko Tokunaga (left). George Hall's cockpit image of a Tomcat in formation can be found in the new "Air Power" (above).

PHILIP MAKANNA

Phil Makanna rode in a Zero to get this shot of two Grumman 'cats for "Ghosts—A Time Remembered" (above). Makanna started out as a painter, but says, "I'm doing nothing but taking pictures of airplanes now." To get "the high-tech airplane against a prehistoric setting" for his newest calendar, Randy Jolly asked the pilot of an F-117 to fly a 90-degree bank.

RANDY JOLLY

of whom started printing the calendars as giveaways to advertise their talents, only to see the idea flower into a profitable business. The sixth, entitled "The Cutting Edge," is the product of Thomasson-Grant, a Charlottesville, Virginia publisher. According to Catherine Pietrow, a company spokesperson, "Of the calendars we publish, it has been far and away the most successful."

Calendars designed around color photographs of military aircraft, from World War II warbirds to modern jets, are the most common. One exception is "Aviation Legends," a new calendar featuring great antiques and classics. Newcomer Michael Terry employs a large-format camera (it produces six- by seven-inch negatives) and comparatively slow shutter speeds. Terry also uses a gyro-stabilizer to steady his lens. The combination produces images of remarkable clarity.

While most photographers seem to be drawn to "air to air" photographs, Baron Wolman of California prefers "air to ground," flying his Cessna 172 close to the earth and capturing what he sees below. His "California From the Air" calendar (the title is taken from a 1981 book he published) is celebrating its 10th year.

Another Californian, George Hall, has been shooting military jets since the 1970s, when a *Flying* magazine assignment took him aloft to photograph Canada's military demonstration team, the Snowbirds. More recently, Hall formed Check Six, a company representing aerial photographers around the world. One of his clients is Katsuhiko Tokunaga of Tokyo, whose shot of an F-14 leads off the series of images shown here. Hall's "Air Power" calendars now include not only his own photographs but those of his clients.

This is the fourth calendar for Randy Jolly.

Baron Wolman was captivated by artist Christo's umbrella construction near Bakersfield, California. Shooting from the ground as the umbrellas were being opened, Wolman said they looked "like flowers opening into bloom." Wolman bought a Cessna 172 in 1980 and started shooting for his "California From the Air" calendar series, now in its 10th year.

The Texas-based founder of Aerographics is currently working on a book about the F-117 stealth fighter, which is how he came to take the photograph included here.

These calendars are representative of the work of a growing community of gifted photographers who are drawn to a wide variety of aerial subjects, and many of their pictures have graced the pages of this magazine in the past. The product of their talents has never looked better.

Portrait and commercial photographer Michael Terry discovered classic aircraft in the early 1980s and never looked back. Among the "Aviation Legends" featured on his first-ever calendar is this 1931 Buhl Bull Pup.

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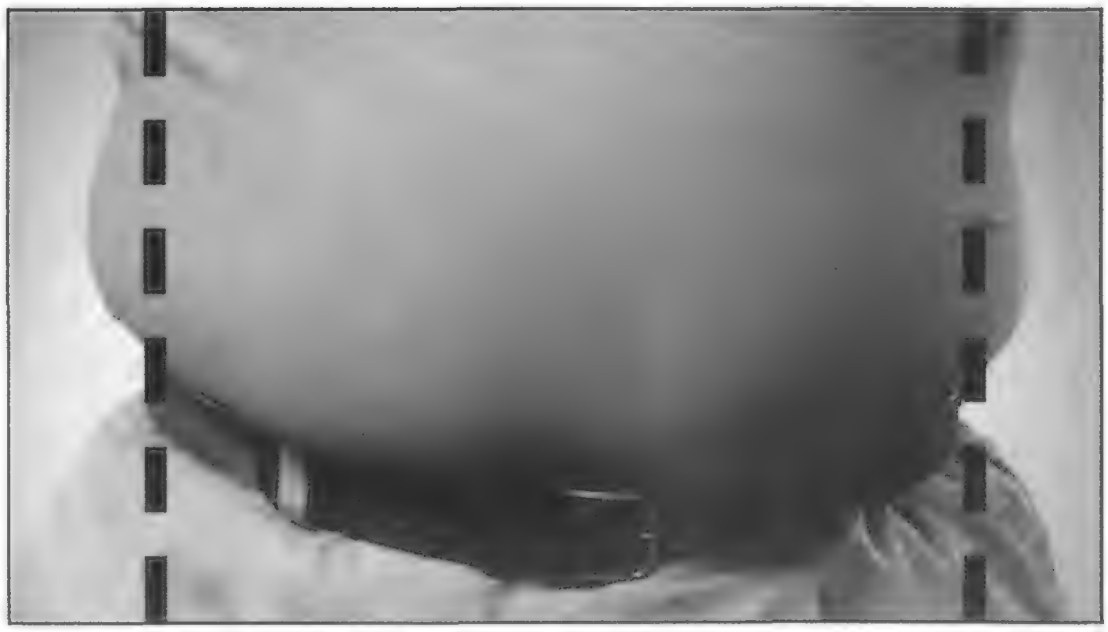

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To penetrate the mysteries of gravity, a team of scientists is preparing the most delicate space experiment ever devised.

THE EINSTEIN TEST

by Frank Kuznik

If the gods of physics smile upon Francis Everitt, sometime before the end of this decade four near-perfect quartz spheres spinning away in supercooled isolation 400 miles above Earth will experience an infinitesimal change in the direction of their spin. It will be a change so absurdly small—the width of a hair is huge by comparison—that for a long time it was thought impossible to measure. No less audacious is what Everitt hopes to prove—or disprove—by quantifying this minuscule movement: Einstein's general theory of relativity.

It's an undertaking that, not surprisingly, has been decades in the making, and it has drawn some of the brightest thinkers in the fields of physics and engineering. It has also attracted its share of criticism, both from the scientific community and from NASA, which is providing most of the funding. Nonetheless, project director Everitt has managed to counter every challenge with compelling evidence of the program's merit. To put it plainly, Everitt is poised to either confirm or overthrow the entire foundation of modern cosmology.

Dramatic as the venture is, you'd never guess as much from a quick look around the project's main offices. The effort is headquartered in an oversized construction trailer—a "modular pavilion" in Californiaspeak—wedged into a corner of a parking lot adjacent to Stanford University's science and engineering buildings. The trailer hums with a lively mix of physics and engineering professors and graduate students. The former are mostly congenial middle-aged men in sport shirts who wax enthusiastic about magnetic torques and gyroscopic drift rates the way most men do about sports; the latter are socially awkward savants in T-shirts and shorts, quietly hunched over computer screens. A total of 100 Stanford staff and students work on the program, which is called Gravity Probe B (Gravity Probe A was a 1976 experiment in which scientists tested the general theory of relativity by comparing the rates of two ultra-precise clocks, one launched into space and one kept on the ground.)

The guts of the GP-B project are crammed into two nearby lab and office buildings, with most of the testing and assembly of the payload being done in what was the first electron linear accelerator, now a series of clean rooms and a maze of equipment, wires, and computers prominently labeled PROPERTY OF THE U.S. GOVERNMENT. Albert Einstein hovers over the entire scene like an ethereal guru, his visage gazing out from pictures on the walls, book covers, GP-B T-shirts, stationery, even the office phone list. A life-size Einstein poster confronts you when you walk in the back door of the trailer. A stand-up cutout of Einstein sits on a shelf in Francis Everitt's office, looking over the GP-B director's shoulder as he talks to visitors.

Illustrations by Barron Storey

Everitt is 58; he wears his black and silver hair down to his shoulders, and he sports a bushy Einsteinian mustache. Speaking in an authoritative British accent, he says, "If you ask me to speculate—Will we confirm or will we deny general relativity?—I must say I'm an experimentalist; all I'm interested in is truth."

Isn't that rather too modest?

"Well, surely it's the right kind of scientific modesty in this circumstance," he replies. "If I were completely modest, or if any of us were completely modest, we wouldn't do an experiment of this kind. But on the other hand, you know, we are undertaking a rather difficult enterprise, which seems worthwhile from many different points of view."

In a nutshell, what the experiment will attempt to do is measure two effects that Einstein's general relativity theory predicts. That theory contradicts Newton's vision of gravity as a force instantaneously traversing great distances and redefines it as a field that warps the space-time fabric. If space and time are woven together the way Einstein envisioned, then the shape of that fabric

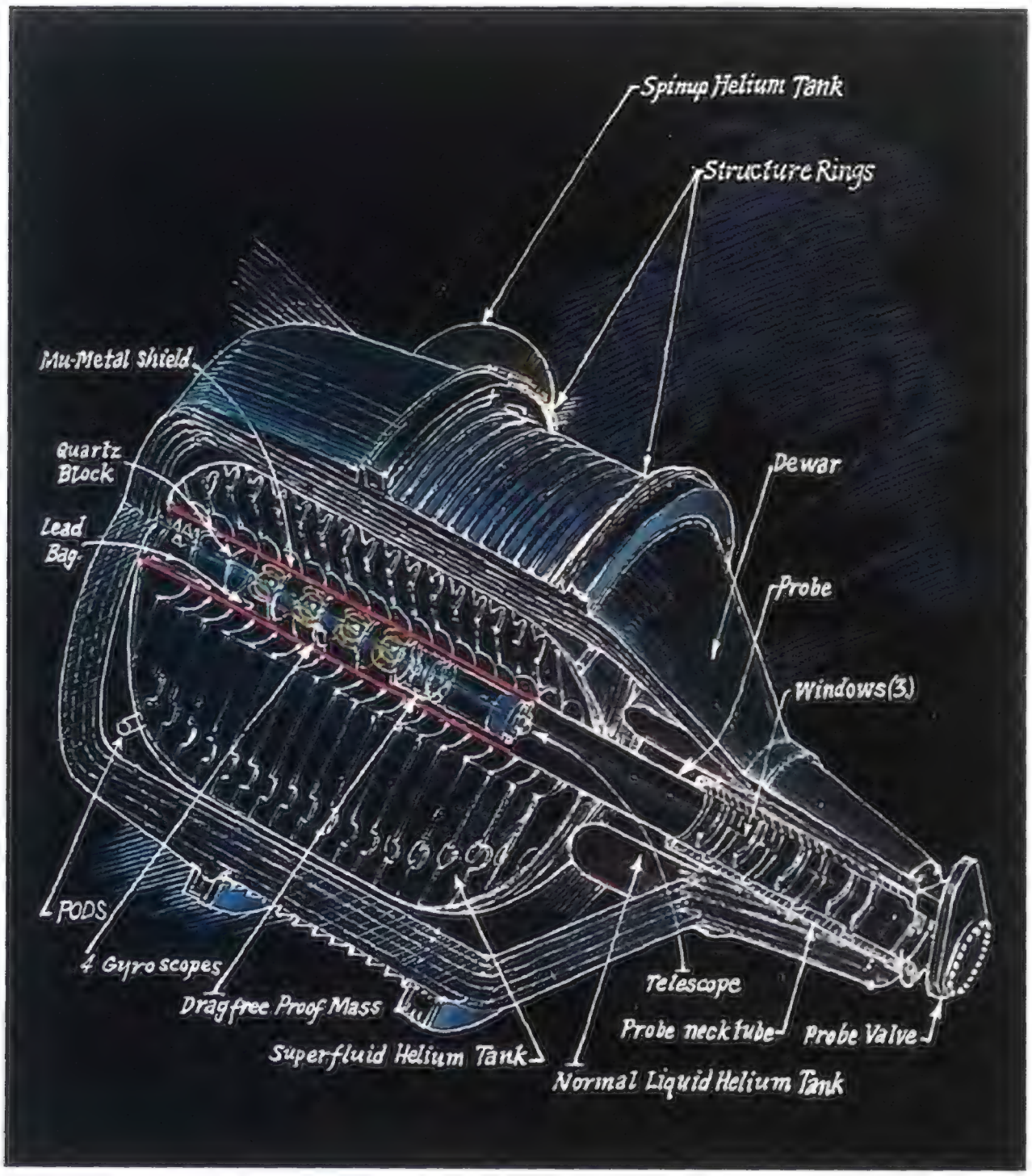
should be affected by the gravitational forces exerted by rotating bodies. A comparatively small body like Earth won't affect the space-time fabric very dramatically; nonetheless, GP-B will try to determine if Earth is exerting the two primary effects Einstein hypothesized. The first is the geodetic effect, the degree to which a planet's mass bends space-time. The second is frame dragging, the degree to which a planet's rotation drags space-time around. Both should be observable in fractions of a milliarc-second, aptly described by one graduate student as "a gnat's whisker of a measurement."

The instrument the GP-B team has devised to detect these effects is basically a large thermos bottle, with 400 gallons of supercooled helium surrounding a nine-foot-long cylindrical "probe." The probe consists of a telescope, which keeps the instrument precisely pointed at a guide star, and four gyroscopes, each a fused-quartz sphere about the size of a Ping-Pong ball and ground to specifications better than one-millionth of an inch. Each gyro will be positioned in a quartz housing containing a superconducting loop. Any change in the direction of a gyro's spin will produce a change in the direction of the sphere's magnetic field that the loop will detect. The entire payload provides a high-vacuum, lead-shielded environment with a temperature near absolute zero. The idea is that if the gyros are sufficiently isolated from such factors as heat, electrical charges, and magnetic fields, any change that occurs in their spin direction can be attributed to the curvature of Einstein's postulated space-time fabric.

GP-B began as a conversation in the late 1950s between three Stanford scientists: Leonard Schiff, William Fairbank, and Robert Cannon. "The original idea was Leonard's," says Cannon, the only one of the three still alive. "He thought it was only a *gedanken* experiment—something you think through but never physically do. Fairbank's contribution was to suggest we do this at zero degrees Kelvin, where everything is supposed to be perfect. Mine was to say we should go into orbit, where we could probably get the gyros' weight down to about a millionth of their Earth weight."

Francis Everitt arrived at Stanford in 1962 as Fairbank's protégé. Over the next five years a working model of the experiment began to emerge, but the problems seemed insurmountable. How could one stabilize an extremely sensitive gyroscope in an orbiting satellite, then keep it near absolute zero for the year or more the experiment would take? How could it possibly be kept free of disturbing outside influences during that time? And assuming all that could be done, how could one ultimately measure submicroscopic changes in the direction of its spin? Everitt recalls the reaction of one contractor NASA hired to check out the project's feasibility: "These guys have got to be kidding."

The solutions evolved over the next two decades (see "The Methuselah Project," February/March 1987). Of considerable help was the development of a system the instrument uses to compensate for even the faintest trace of drag from Earth's atmosphere. The system relies on a quartz sphere (identical to one of the gyros) that is kept shielded from external accelerations in a cavity near the spacecraft's center of mass. Because it is so well isolated, the



The Gravity Probe B instrument is essentially a thermos bottle (also called a dewar) containing four near-perfect spinning spheres and a telescope that keeps the instrument sighted on a reference star. The ensemble provides an environment of low acceleration, low temperature, low pressure, and low magnetic field—all conditions necessary to enable detection of the slightest changes in the spheres' rotation.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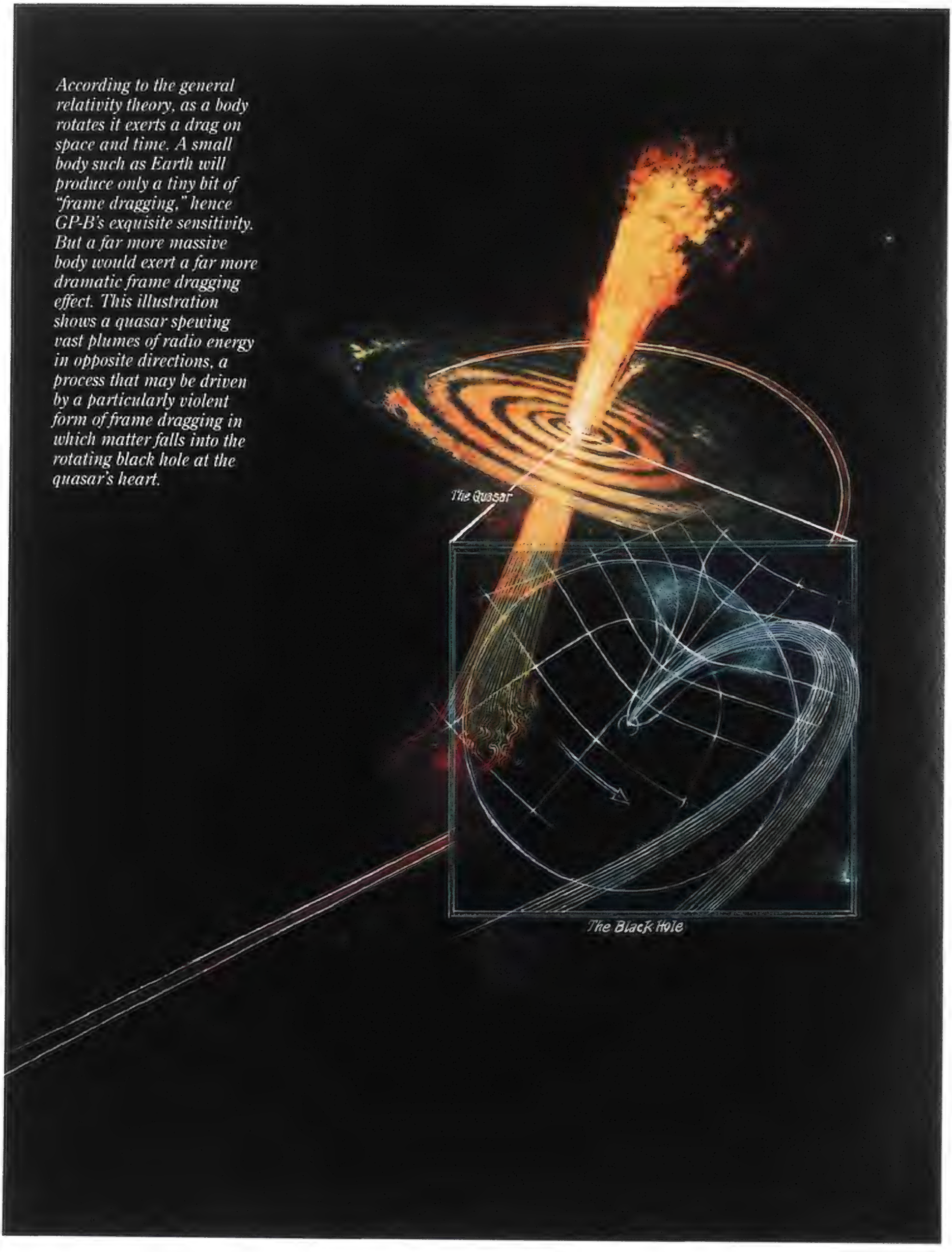
According to the general relativity theory, as a body rotates it exerts a drag on space and time. A small body such as Earth will produce only a tiny bit of "frame dragging," hence GP-B's exquisite sensitivity. But a far more massive body would exert a far more dramatic frame dragging effect. This illustration shows a quasar spewing vast plumes of radio energy in opposite directions, a process that may be driven by a particularly violent form of frame dragging in which matter falls into the rotating black hole at the quasar's heart.



sphere follows an ideal gravitational orbit; the spacecraft, sensing the reference sphere's position, will continually apply thrust forces to "chase after" the sphere, and thus end up moving in a near-perfect orbit itself.

More than a dozen technologies and engineering methods have emerged from the GP-B program, as well as 44 Ph.D.'s, five engineering degrees, and 12 master's degrees. With most of the conceptual and technical hurdles behind them and the launch of the instrument tentatively scheduled for 1998, the project team is now working on refining individual components—for example, nudging the quartz gyroscopes—already the roundest objects ever made—a few ten-millionths of an inch closer to perfect sphericity, and integrating them into a working whole.

That approach is itself noteworthy. Space hardware is often designed and built direct from drawing board to finished product, using components and systems with some flight history. GP-B doesn't have that luxury—nor does it have any margin for error. "This is not a straightforward engineering task," says John Turneaure, a co-principal investigator on the project. After working out the design concept, the team developed small portions of the hardware and demonstrated that each would work. Next, they put these pieces together in small groups for subsystem testing and finally assembled the subsystems in order to test the workings of the complete instrument.

In practical terms that means the team has had to build, test, and refine two prototypes of the GP-B probe that will never even fly in space. A scaled-down version of the probe, designed to test the gyroscopes' performance in low gravity, is scheduled to fly on the shuttle in 1995.

Then there's the nightmarish "Gravity Probe B Error Tree" to consider. That's a poster that shows 177 boxes representing factors that could affect GP-B's final measurements. On a mission where a random gas molecule in the instrument or too much sloshing of the liquid helium could queer the whole thing, the tolerances for each of those 177 factors must be excruciatingly fine to guarantee valid results. Says science mission project manager Jeremy Kasdin, whose office displays the poster, "The idea is to make sure we've tracked all the errors, understand them, and can drive them down." But always there is the overarching question: What if the gyroscopes get rocked by a disturbance no one had foreseen?

Everitt has obviously fielded this question before. He fairly leaps to the board in his office and launches into an hour-long lecture on the checks, cross-checks, and redundancies built into GP-B, as well as the years he and his colleagues have spent considering the possible effects of everything from cosmic rays to micrometeoroids—at the end of which he says, "So I've really just given you flavors, rather than a detailed argument, of why I think the results of this experiment will be very believable."

This, when you talk to the GP-B team, is the hope they profess. Not to overthrow Einstein. Not to lay the foundation for a new theory of the universe. "I'd like to see experimental results with very low uncertainty and internal consistency which other scientists will believe," says John Turneaure.

But that's just the problem, say some critics of GP-B, who contend that the vast majority of the scientific community already believes the theory of general relativity. It's been supported by increasingly sophisticated astronomical observations, say these critics; GP-B is a risky, one-shot experiment that can't be corroborated by another, so why not spend our money in a potentially more productive area?

To which Everitt and his team reply that, accepted or not, Einstein's theory needs revision. For one thing, it doesn't square with quantum mechanics. Furthermore, while Einstein's theory of special relativity, which weaved space and time together and produced the famous equation $E = mc^2$, is well verified, his theory of general relativity isn't. Though a few observations confirm certain aspects of general relativity (see "The Case for Einstein," above), important aspects of the theory have yet to be tested by traditional scientific experimentation. Given a chance to do that—to achieve some results that are unprecedented in their precision and others that are altogether unique—why not try?

Everitt sums up his position with a classic bit of British understatement: "Here's all we can say: That we're pressing into a new and interesting area where we know eventually something has to be found. We do not know whether GP-B will find that something. But nobody at the moment has any much better

The Case for Einstein

While a number of competing theories of gravity have been knocked out of the ring, the theory of general relativity has yet to be irrefutably verified. Still, several observations and experiments over the years have given weight to what physicists consider the most beautiful and profound scientific theory of this century:

- Each time the planet Mercury orbits the sun, its perihelion—the point at which the planet comes closest to the sun—advances a tiny bit. Such orbital advances could be attributed to the gravitational effects of the other planets in the solar system; however, Mercury's advance is too great for this explanation to suffice. Instead, it appears that the massive gravity of the sun is warping the space around itself, producing a depression that the planets have to follow. Because Mercury is the planet closest to the sun, its orbit shows the effects of this depression most dramatically.
- Einstein believed that a massive body can also bend starlight passing near it. To test this, astronomers twice measured the locations of a group of stars: once during a 1919 solar eclipse, in which the sun was positioned between Earth and the stars, and again under normal conditions, when the sun was not in this intermediate position. A comparison of the readings showed that the eclipse seemed to have caused the stars to shift. The explanation? During the eclipse, the stars' light had had to pass close to the massive sun—and thus through the warped space surrounding it—before reaching Earth.
- In a related series of tests conducted in the 1960s and '70s, scientists targeted radar signals at various objects in space: planets, spacecraft, and finally the Viking lander that had been left on Mars. When the researchers measured the amount of time it took for the signals to reach the targets and then bounce back, they discovered that the transit time was a bit longer than would have been the case had the signal merely traveled a straight line. The delay was attributed to a curvature in space.

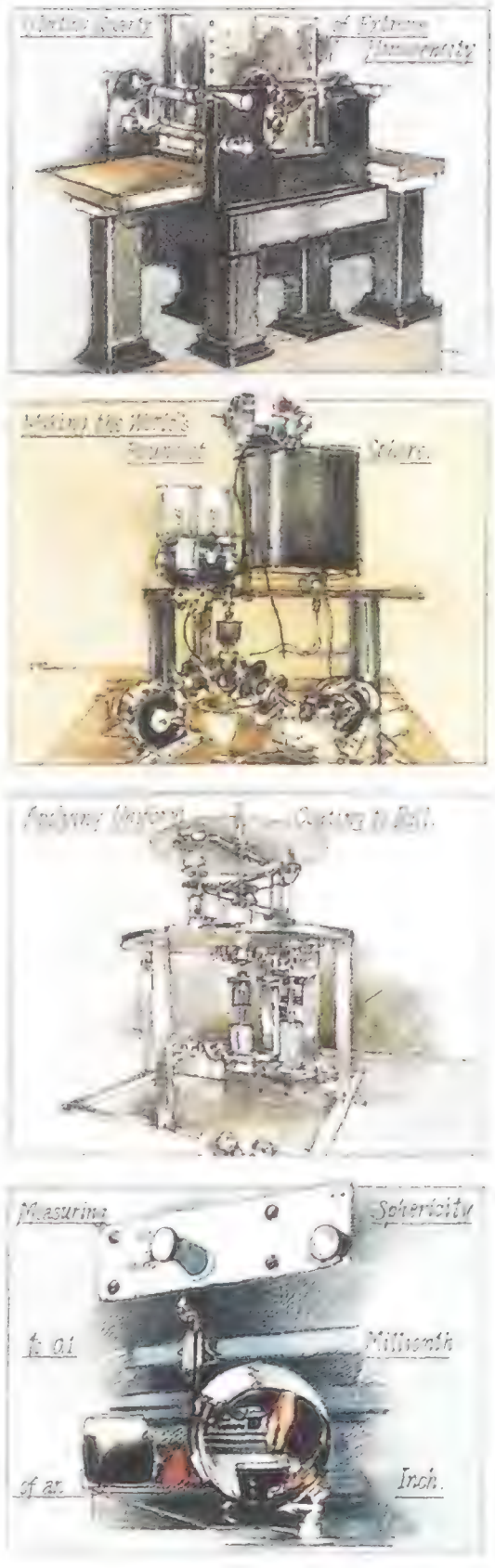
ideas about where to find something, so maybe let's press on."

NASA's support for GP-B has run hot and cold. At one time then-administrator James Fletcher reportedly told a subordinate arguing for the program, "We've got the technology from it, let's just cancel it." Today more people seem to echo the sentiments of Charles Pellerin, formerly NASA's astrophysics director, who says, "I'd like to see it happen. But I've also created forums where we have discussions about it, because I felt the most important thing was to get the truth on the table, and let's all make decisions based on truth."

That's meant an endless series of review committees trooping through Stanford, most skeptical about GP-B when they started, almost all laudatory by the time they finished. Perhaps the most threatening group was convened early last year. "This was the committee to end all committees," says program manager Brad Parkinson, a co-principal investigator on the project and, before that, one of the founders of the Global Positioning System. "Everyone who had ever breathed a strong word against us was put on this committee."

The preliminary draft of the committee's report came down hard against continuing the project. Essentially, the committee was concerned about the possibility that GP-B might yield results differing from earlier experimental tests of general relativity. In such an instance, said the report, it would be hard to conceive of an alternative theory that could account for the discrepancy. In response, Everitt swung into action, sending copies of the draft to over a dozen of the world's top gravitational physicists. They in turn bombarded the head of the committee with glowing reviews of GP-B. Robert Reasenberg of the Harvard-Smithsonian Center for Astrophysics: "...a scientific and technological *tour de force*.... This superb work offers NASA the opportunity for a significant success...." John Wheeler of Princeton: "...it will cast a brilliant light on marvels of new technology and of new measurement technique destined to have beneficial impact all across the spectrum of human endeavor." And so on.

The committee's final report ended up backing the project. So did NASA's Space Science and Applications Advisory Committee when it met a few months later. But when the most recent NASA budget got to Congress, GP-B, along with several other research programs, hadn't made the cut.



Regardless of how it ultimately affects our understanding of the cosmos, the GP-B program has already succeeded in pushing the envelope of space technology engineering.

"I thought our troubles were over—it was really a surprise to me that we were canceled this year," Everitt says with a sigh. "GP-B has been canceled six times since 1980, all in different ways by different people, never by the same person twice for the same reasons."

As a result, Everitt has had to become a lobbyist. Arguably the best known face from Stanford on Capitol Hill, he spends a good chunk of time in Washington every year persuading Congressmen and committee staffers to put GP-B back in the NASA budget. And he has an expert partner in Parkinson, who was nicknamed "Silver Tongue" for his lobbying efforts inside the Department of Defense when he was selling the Global Positioning System.

The two have done an impressive job. For one thing, the latest threat has been overcome, with the program being restored for fiscal year 1993. Says David Gilman, NASA program manager for GP-B, "To show you how strong Congressional support has been, the [previous] two times Congress restored funding for GP-B it's been an outright gift to NASA. It's really exceptional when that happens."

Still, living and dying every year by the NASA budget sword takes a toll. "I think we're used to the turmoil," says Parkinson, "but it's a nuisance and a hell of a lot of work for us. And it always puts you in 'The Perils of Pauline,' with a train hurtling down the track toward you. It's a tough problem not to lose your nerve." Everitt seems more disconcerted than nervous. Asked how he would define his job, he smiles wanly and says, "I'm not quite sure what I consider myself. Sometimes I consider myself to be a traveling salesman."

He pauses for a reflective moment. Everitt's in classic nutty professor attire today—dress shoes, baggy suit pants, and black long-sleeved Gravity Probe B T-shirt with Einstein's calm, disheveled visage. He takes off his glasses and says, "I think the thing that kept me going through the dark times was that we were both in the process of inventing some new technology and knowing that if we pulled the experiment off, we would be doing something very fundamental, which seems to me an ideal match. Of course, I never imagined it would take us this long."

When and if GP-B finally gets off the ground, the only thing that might rival its results for sheer drama is the project's 40-year history of technical hurdles, political mayhem, and impossible dreams come true.

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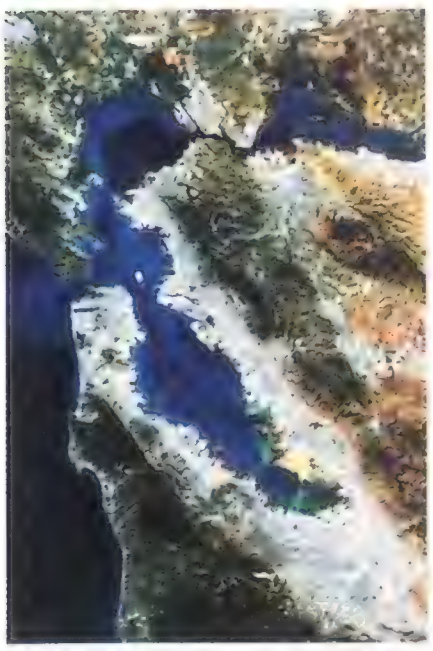

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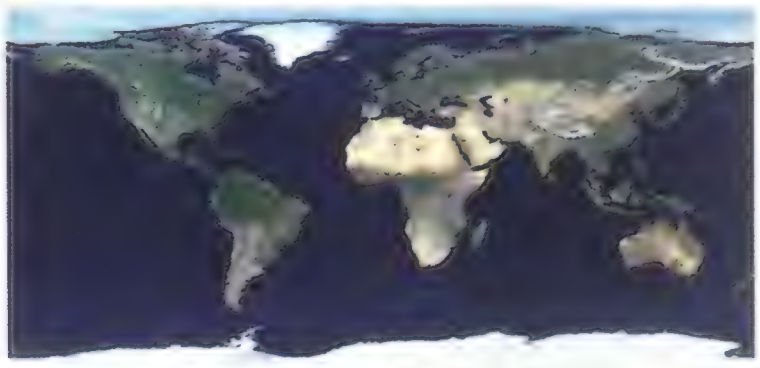

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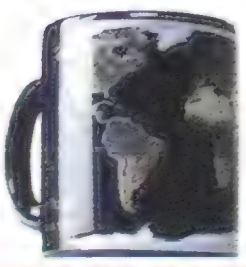

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WIDE

How an airliner arose out of the best of circles.

From the book *WIDE-BODY: The Triumph of the 747.* Copyright ©1993 by Clive Irving.
To be published in January by William Morrow & Co., Inc.

PHOTOGRAPHS COURTESY BOEING

BODY

In 1963, in response to development of the European Concorde, President John F. Kennedy launched a U.S. effort to develop a supersonic transport. To provide an interim airplane until the SST was available, the Boeing company, prodded by Pan American chief executive Juan Trippe, began work on a large subsonic airliner designated the 747.

by Clive Irving

When Boeing engineer Joe Sutter took his seat behind a desk to pick up the 747 as a work in progress, he was making $29,565 a year—a handy sum by 1965 standards but somewhat less than competitors might have paid for a man with such a depth of experience in commercial jets. Boeing was not then a big payer; in California, where there was always another aerospace company to go to, there was a more active market in top engineers, but in Seattle defections were very rare—company loyalty was part of a tie to the city and its way of life.

Boeing chief executive William Allen certainly set an example in conservative salaries: in 1965 he was paid $99,600. (During his tenancy as president of Boeing, Allen never took

When the Boeing 747 debuted in February 1969, its combination of size and speed promised airlines a new era.

home more than $150,000 a year, whereas Donald Douglas was paying himself $120,000 way back in the middle of World War II.) Edward Wells, the company's most dominant engineer since the days of the B-17 and at the peak of his career, made $77,100. Nor was it a company stacked with vice presidents. Although Sutter had been asked to take a job in which his judgment might well involve the very survival of Boeing, there was no prospect of his being given a vice presidency. The commercial airplane division had only nine vice presidents, including the top of its shallow pyramid, the general manager and his two assistants. (Wells ranged over the whole company, military and commercial, as vice president of product development.)

As chief engineer for the 747, Sutter reported to the vice president of engineering, George Snyder, a longtime manager who had risen by seniority rather than by any significant flashes of brilliance. Sutter could ask for particular engineers he wanted, but another engineering vice president, Dick Rouzie, was hand-picking engineers for the 747 from a list of the best men orphaned by Boeing's loss of the C-5A heavy lifter program to Lockheed. Sutter was expected to take whoever came.

The commercial division's lean hierarchy ran a nondescript collection of offices and plants in Renton, Washington, a singularly featureless town that had originally grown out of a mining settlement. The headquarters complex at Boeing Field, apart from the one Deco flourish of the executive building allowed in the late '30s, had never been better than merely functional; the Renton sprawl, divided from Boeing Field by a thin ridge of hills, was (and still is) even less prepossessing. One senses the art of arrogant self-denial. A statement is being made that the business at hand is too serious to permit distracting corporate frills.

Certainly the birthplace of the 747 program was not spiritually arousing. Sutter and his team had the second floor of what was called the 1085 Building in Renton, no more than a basic Boeing drawing office, with metal desks and strip lighting, which clearly granted no right of permanence. Programs and people came and went, some leaving no trace. In such a place it was inevitable that in the fall of 1965 the hundred or so men working with Sutter had the sense of being transients, headed for either glory in the big sky or another false dawn.

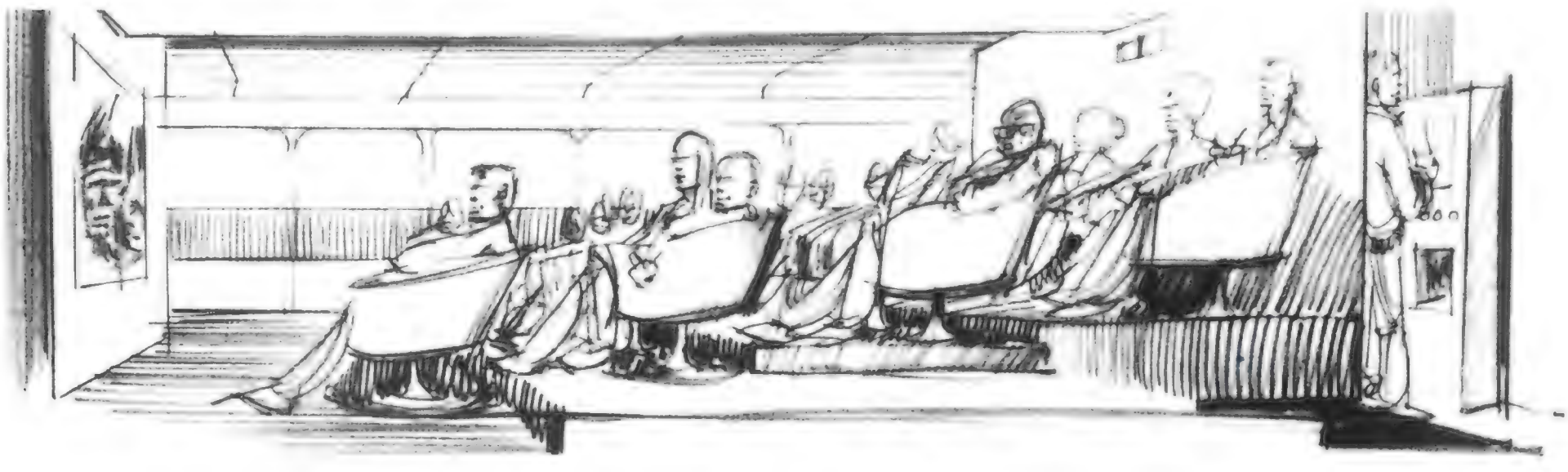
Of the men already in place when Sutter arrived, the one he was most glad to see was Row Brown, who ran a small team charged to explore every possible configuration for the airplane. Brown was a man who retreated from the faintest beam of limelight and the polar opposite of Jack Steiner, who had led development of the 727. But Sutter regarded Brown as the best airplane developer he had ever known. Brown had gradually emerged as a man with a forte of his own; he originally worked as an aerodynamicist on the B-47 wing, and later moved into preliminary design. Brown's configuration group had been switched to the 747 from the C-5A as soon as Allen was told Boeing had lost the contract. "We had been sitting around with the blues," one of them told me, "but by two o'clock in the afternoon we went to work on the 747."

Configuration men were always the first over the threshold of a new program. Their objective was to size the airplane according to its intended payload. They considered the implications of the load it had to lift, both in passengers and cargo, and how it would be manageable on the ground. Everything that was subsequently required of the design grew from this chrysalis. The airplane that Boeing had discussed with Pan Am's intimidating engineer, John Borger, and Juan Trippe's martinet negotiator, General Laurence S. Kuter, back in July had remained amorphous until Brown's unit was assigned to it. Boeing had talked to Pan Am of a "new technology" airplane. As well as the engines, this included, in their minds, the work done at Boeing on large structures in developing the C-5A.

Configuration was a process best carried out with an un-

Joe Sutter (above) inherited some engineers already at work on the new airliner; others came from the C-5A program.

From the start, the new aircraft was envisioned as capacious, but this theater didn't make the final cut.



sentimental eye, relentlessly fixed on numbers. The 747, as proposed to Brown, was expressly utilitarian—first a large-capacity airliner with generous space for cargo, then, when the SST supplanted it, capable of being used solely as a freighter. Or, in the words of one of Brown's staff, the job was to "sell 'em, build 'em, use 'em, and change 'em."

But within days, before Sutter had had a chance to assess the ideas that had been sketched out for the 747, he found the range of his own role being challenged. Rouzie called to say he was sending over a hundred more engineers from the C-5A. Among them were specialists who, if the program accelerated, would lead teams on things like the power plant, controls, and systems. One was openly more ambitious than the rest: Fred Maxam. Maxam had worked with Sutter on the 727. During the development of the C-5A, Maxam had worked under the eye of Wells (few key decisions on the C-5A were taken without Wells' blessing), and Sutter now realized that Maxam was acting like a man who believed he was a Wells favorite.

Maxam, although reporting to Sutter as his assistant, announced—implying that he was speaking for Wells—that because Sutter had developed a good rapport with the airlines, and particularly with Pan Am, Sutter should be the outside face of the 747 program, while Maxam got on and designed the airplane.

This was news to Sutter. "Jeez," he said, "is that what you heard?"

Not only that, but on the basis of the very first sketches done by Row Brown's configuration group, Maxam had already made up his mind on the 747's configuration: it should have a double-deck fuselage. This was the simplest way to more than double the passenger capacity of the 707: six-abreast seating on two decks. Even then, to provide the 350 to 400 seats they were talking about, the fuselage would have to be very long. Two long, narrow tubes.

Sutter didn't like this idea on sight: to evacuate the airplane in an emergency would require escape chutes on two levels, with passengers on the upper deck facing something like an Olympic bobsled ride.

But Maxam had support for his concept from outside Boeing. Juan Trippe had leaped at the very phrase "double-decker," which to him had the ring of a great marketing slogan. Douglas was also talking double-decker. In fact, the conventional wisdom of the hour had really never considered anything else—the engineers were inclined to see the six-abreast cabin as a standard, and to add seats you either did the big stretch, as Douglas had with the DC-8, or you put another deck on top. Sutter's gut feeling was that the double-decker was misconceived. A gut feeling, however, did not amount to a viable technical argument. Sutter couldn't kill the double-decker without an alternative idea, and since it was the only idea they had, the double-decker was unchallenged all the way up to Wells.

The translation of performance targets into an airplane was a process that invited many arguments. An airplane of this size was unprecedented, and the arguments therefore multiplied. Palpably overhanging every idea that Sutter explored was the responsibility for potentially putting at risk more than twice the number of lives that any designer had ever had on his conscience. Sutter was known for being ultraconservative on structural integrity, always positing the worst-case scenarios and wanting "redundancy"—an extra margin that might never be needed but if it ever was would avoid catastrophe.

As well as the concern for safety, an airplane of this size—even as an intangible notion—carried political liabilities. As Sutter pondered the 747 configuration, he knew that there

The aesthetically pleasing and space-efficient spiral staircase survived, but the lounge was filled with seats.

was hardly a single technical step that did not carry a political consequence. Noise, for one. Jets of the 707 generation left a rasping and penetrating wake of sound as they took off, and airport noise had provoked an increasingly powerful backlash from communities under the flight paths. These same jet engines were also dirty: they trailed sooty ribbons of imperfectly combusted kerosene.

But perhaps the most contentious matter was the impact the 747 would have on airports and air traffic movements. The global boom in air travel had already overpowered the capacity of many airports. And in a lot of the municipal airports around the United States, Boeing 727s and Douglas DC-9s came with such frequency and with such loads that they stretched out in lines waiting for takeoff like cabs on a rank. How would a monster carrying three to four hundred people help this?

Every 747, went the rehearsed answer, would remove the need for up to two out of three smaller aircraft. But the 747 was a transcontinental and transoceanic jet, and would not reduce aircraft numbers on congested domestic hops. Never mind, went the Boeing refrain; on the long-haul routes 747s could cut the number of individual departures by nearly 40 percent, and anything is better than nothing.

Sutter had arrived too late to stop the production of scale models demonstrating the virtues of the double-decker. There were several versions, and Sutter had a word for all of them—turkeys. One had a mid-wing arrangement, in which the lower deck was actually interrupted by the wing structure. Sutter had long ago memorized every detail of Boeing's visionary but commercially disastrous 247 airliner and recalled that one of its most serious flaws had been the main wing spar running through the middle of the passenger cabin like a giant step. Some guys never learn, steamed Sutter. He didn't like the low-wing version of the same design any better—it looked ungainly and top-heavy.

Opposite: The Boeing-Pan Am relationship was anchored in the bond between William Allen (left) and Juan Trippe.

Even as airplanes rolled out for completion, the full impact of the 747's size on airport operations had yet to be felt.

There was another model showing three engines instead of four, all three clustered at the rear as on the 727, with a high T-tail. (Wells, for some reason, always liked T-tails even though they involved tiresome aerodynamic and structural complications.) This one looked rear-heavy, a big pain in the butt. But the most peculiar proposal was a model they called the "anteater" because its flight deck was actually placed under the passenger cabin. Passengers at the very front had windows curving around the nose so that they would be sitting where the pilots normally were, looking forward! Below them, the pilots would find themselves enjoying an uncomfortable intimacy with the ground on takeoff and landing.

Yet of all these models, the anteater had redeeming qualities. It was not a double-decker. If you overlooked the aberration at the nose, it was far sleeker than the others and had the kind of natural balance to it that Sutter always looked for. (A maxim from the earliest days of flight was "If it looks right it will fly right," and Sutter had no argument with that.) Moreover, there was a method of a sort in the madness of the nose. If its future after the SST was to be a cargo carrier, getting the flight deck out of the way of the main passenger cabin was an inspired stroke. Cargo could be front-loaded through a hinged nose. As far as Sutter was concerned, the anteater was still a no-no, but it was suggestive of an idea.

The airplane that the Boeing team had talked about to Pan Am on September 30 was no more tangible than the one suggested in the July meeting. Nobody expected that it would be, and the 747 remained evanescent in a five-page letter to Pan Am at the end of October. Boeing was offering an envelope: so many passengers, so much range, such a cost per seat-mile. A detail that caught Borger's eye, a cruising speed of .9 Mach, had not given Sutter pause. Of the many things on his mind at the time, it didn't seem an issue.

Fred Maxam, however, was an issue. Sutter was tired of hearing how Maxam was going to run the project. He called Rouzie with a simple choice: "It's either me or him." Within two weeks, Maxam had gone—to the SST team. To the few hundred engineers now gathered in the pastures of the 1085 Building, there was no lingering doubt about who was in charge. And beyond Sutter's team, it was a detectable signal that the 747 was being driven by a single-minded engineer who wanted no ambiguities in lines of responsibility.

Sutter had been picking his core team.

One Friday afternoon Milt Heinemann was slipping a round-trip ticket to Alaska into his briefcase. Like Row Brown, Heinemann was valued as a self-taught specialist; in his case it was cabin design. Heinemann had been working on the troubled 737 program. Ward Air, the Canadian company that serviced the Alaskan North Slope oil explorations, was pressing to know if the 737 would be able to use the gravel runways that had been laid down in Alaska. Boeing's technical staff balked. Throw rocks into a $2 million engine? No way. Heinemann, diverted from cabin design, was asked to find out whether gravel runways could somehow be dealt with. It was the kind of problem he liked.

Rouzie came into his office. Sutter wanted Heinemann on the 747—right away. There was no appeal. Somebody else could go and test the gravel in Alaska.

As the authority on cabin layout, Heinemann found himself dropped into the center of the argument about the double-decker. Although Maxam was gone, the double-decker had gathered alarming momentum. A brochure featuring it had been prepared for the airlines. Its advocates pointed out that airports were running out of ramp space and that it would be a lot easier to turn around an airplane that was twice as tall than one that was twice as long—length and height were, significantly, the only dimensions anyone seemed able to project.

Like Sutter, Heinemann distrusted the double-decker on sight. And he voiced his concern: two hundred or more people up 35 to 40 feet from the ground and he had to have them all evacuated within 90 seconds—the time laid down by the Federal Aviation Administration as mandatory—without injury? Just how was that going to be done? Nobody had an answer. It was his problem. They were already building a wooden mockup of the double-deck fuselage to show to the airlines.

But Heinemann knew that he enjoyed one inviolate instrument of power over the project—Boeing would withhold approval of any design until he was prepared to take responsibility for the evacuation of the passengers by the 90-second rule. Sutter knew that Heinemann would never compromise on that. It was one of the reasons Sutter had had him pulled from the 737 program. And Sutter had another ally against the double-decker.

Row Brown was iterating the configuration like mad, never seeming satisfied with the results. Torrents of drawings spewed forth. Brown was approaching his two hundredth attempt at reconciling the payload with the performance. He was thinking of cargo as well as passengers. Word had come down from Allen, reemphasizing that if the 747 went ahead,

"all the family jewels" would be tied up in it, that the engineers would have only one shot to get it right, and that included making sure that they made the design as flexible and versatile as possible. That meant not losing sight of its destiny as a freighter—jibes about the 747 being a Mack truck were given tangible form.

Allen's emphasis on the freighter came directly from conversations with Trippe. Trippe had told him that as a passenger carrier alone, the 747 "would be very difficult to assimilate." Pan Am had presciently figured that if seat-per-mile costs were as drastically reduced as Boeing said they would be, so also would be the cost of shipping cargo, and that there was a large worldwide demand for the rapid delivery of liftable freight.

The double-decker didn't impress Brown as a freighter, any more than it impressed Heinemann as a way of safely seating four hundred or more passengers. In the minds of Sutter, Brown, and Heinemann it was coming down to one decision before all others: the cross section of the fuselage. If they got that wrong, it wouldn't matter what else was right.

There were lots of uncomfortable phantoms in their technical memory. Heinemann and Sutter could recall full well the crisis days of the 707's cross-section, when the difference between success and failure had been measured in inches. In a large bay at the back of the executive offices at Renton they looked at the completed wooden mockup of the double-decker. It generated excitement by its sheer scale. Maybe this was a glimpse of the future, but to Sutter it was still a turkey, just a very large one.

At Pan Am, Trippe was turning the screw. He wanted the big jet as fast as he could get it. Nobody had so far calculated what a 747 might cost. Pan Am was even now buying more 707s, the model 321B, at $7 million apiece. The crudest extrapolation, that the 747 would be two and a half times larger, suggested that it could not cost less than $17 or $18 mil-

Project pilot Jack Wadell (flying copilot) made the 747's first flight shepherding prospective customers (opposite).

As competition for sales heated up, the normally staid Boeing staged more flamboyant P.R. events like this rollout.

lion. So, in talking of an initial order of twenty-five 747s, Trippe was breezily talking about committing Pan Am to an investment of $450 million in one airplane. That excluded the cost of spares and the conversions of airport piers and maintenance plant that would be needed. No airline had ever talked in such terms before, and this was an airplane that did not exist, that as yet had no engines, that no airport was equipped to take.

Trippe was, however, riding the euphoria of a good year. Every indication was that for the first time, Pan Am's earnings would top $50 million. (It had been a long journey: in its first year as a mail carrier, Pan Am had lost $300,000; by 1932 it turned its first profit, $100,000, but Trippe had always spent lavishly on new airplanes.)

Allen understood full well that Trippe's talking of such a large initial order was a coercive step, in keeping with his manner of doing business. In effect, Trippe was offering Allen the launch order for the 747. Two things would inevitably follow: Trippe would want sufficient priority in deliveries over all other airlines to establish an early dominance with the 747, and Pan Am's engineers, led by Borger, would be crawling all over Boeing's engineers as they designed the airplane.

In an October letter there was only one mention of engines, that Boeing and Pan Am would resolve the engine selection by January 3, 1966. But the truth was that there was no engine for the airplane. Trippe wanted General Electric's big-fan engine, designed for the C-5A. Its development was being paid for by the military, and Trippe was always anxious to ride on the back of a Pentagon program. Furthermore, Trippe knew that Pratt & Whitney's management was nervous about what it would cost to get into the race with GE. He was doubtful that Pratt could handle further development of its prototype big-fan engine.

John Borger, who was in no position to question openly Trippe's preference for the GE engine, nonetheless knew that it just would not fit the 747 as Boeing was describing it. For one thing, it was designed for the C-5A's lower cruising speed of .78 Mach, and an engine designed for one cruising speed could not simply be "tweaked" to fit another. Borger also suspected—rightly, as it turned out—that in meeting the unsentimental military criteria the GE engine would be a "smoker," and noisy. Although Pratt was fearful of the investment involved, and sensibly dubious that its first big fan could be developed at the same speed as a new airplane (all the historical evidence being to the contrary), it did make a philosophical decision about the design that was astute.

The GE engine had a very high bypass ratio (the ratio of the uncombusted cool fan air to the hot core air) of eight to one. The company's confidence that its engineers could figure out how to hold this engine together had been well placed. Pratt, on the other hand, felt that it could get a more flexible engine, and one more suited to the commercial ambitions of the 747, with a lower ratio. Pratt chose a ratio of five and a half to one. And so by the end of October, Pratt, like Boeing and Pan Am, was suppressing its best instincts and marching to the tune of Juan Trippe—step by step into the bold new world of the megajet.

Between them, these companies were making a financial commitment beyond the bounds of anything known outside of a military program. John Kennedy's invocation that America would put a man on the moon by the end of the decade testified to one aspect of the national spirit and will, that which was ready to restore America's pride at any price. There was no such simple and clearly defined objective to the 747 program, but the fiscal insouciance behind it was certainly heroic. Except the company treasurers were quaking in their shoes.

Row Brown persisted with the 747's freight-carrying role. A new international standard for freight containers had been arrived at: a cross section of eight feet by eight feet. This was done to achieve commonality between road, rail, and ship cargo—the containers would vary in length according to conveyance, but not in width and height. The average container was built to be indestructible, as far from the finesse of airplane construction as the Brooklyn Bridge. Brown knew that these monsters could never be levitated by an airplane. But it seemed to him that there was a lot to be said for designing the lightweight container for air cargo to the same common dimension, the eight-foot square. Cargo could then simply be switched from one container to the other without being reconfigured.

How would this fit into the cargo hold of an airplane? Idly sketching, Brown drew an outline for the belly of a 747 around one freight container, but it looked a little lonely. Brown drew in two side by side. He figured out the required width of the cargo deck's floor. Then he drew a circle to fit snugly around the deck and the containers.

Sutter, Heinemann, and Brown looked at Brown's circle. And then they looked at each other. It was a fuselage. A very

Its European contemporary, the supersonic Concorde, had twice its speed, but the 747 had a cabin capacity that won the market.

wide fuselage—more than 20 feet across at the level of the passenger cabin, sitting above the cargo deck. Nobody had ever dreamed of a passenger cabin as wide as this—nearly twice as wide as the 707. Boy, was it wide. Without consciously registering the moment—there was no cry of "Eureka!"—they knew they had iterated their way to the most daring solution of the 747's configuration problems.

It might seem odd that it had taken Brown so long to arrive at this solution, because he had previously configured another airplane with a similarly fat body, the C-5A. But that was a military transport, constructed for very different loads. Although there was a superficial similarity between the C-5A's fuselage and the 747 that had now evolved, it had never occurred to anyone to start with a fuselage of this dimension for the airliner.

It was Sutter's inclination, given the pressures on him, to design the 747 well within Boeing's accumulated body of knowledge. To his mind, the 747 was inside the skin of the 707, waiting to burst out. The basic outline of the 707 was too good to fool around with. Sure, they could tailor it better with the latest wind tunnel tricks, but to hell with T-tails, anteaters, and all the other turkeys. If you scaled up a 707 and superimposed on it Row Brown's wide body, it didn't get out of scale. It looked right.

With Wells persuaded, someone had to begin the process of weaning Trippe away from the double-decker. Sutter knew that Borger, swayed by the advantage in cargo capacity, favored the single deck. Sutter decided that Milt Heinemann, whose manner manifested a nice balance of the venal (payload) with the steadfastly moral (safe evacuation), was more likely to get Trippe's attention than someone from the sales staff.

Heinemann bought a piece of hemp rope, a quarter of an inch thick and 35 feet long, at a hardware store in Seattle. He tied two knots in it, one at 20 feet and the other at 29 feet. He stuffed the rope in his briefcase along with a wad of documents, not knowing quite how he was going to use it. Then he took a flight to New York.

The next morning, Heinemann was meeting Trippe in the boardroom of Pan Am on the 52nd floor of the 59-story Pan Am building in New York. Heinemann had been sent to New York to get Trippe to change his mind. Heinemann deliberately arrived early at the Pan Am building and got a secretary to let him into the boardroom. The table ran the length of the room, and at the end, on the room's short dimension, there were floor-to-ceiling windows. Heinemann rolled back the blinds. You could look straight down the center of Park Avenue, feeling for a second as if you owned the city. He pulled out the rope from his briefcase.

Stretching it wall-to-wall across the windows, Heinemann noted that the boardroom was only barely wider than the 20 feet marked by one of the knots on the rope. He hadn't dared to hope he would be that close. He pulled out a chair from the table and stood on it (he was short and stocky), stretching to the ceiling with the rope. The room was a tad higher than the nine-foot measure to the next knot. Heinemann couldn't believe his luck; this was the scenario he had dreamed of. He stuffed the rope back in his case, pulled out his papers, and sat down.

A little later, Trippe came in with a small retinue. After the formalities, Trippe and the others sat down across the table from Heinemann, waiting.

"Gentlemen," said Heinemann, "this airplane is two and a half times the size of the 707. We could be talking of carrying five hundred people. That's the basis for the economics of the airplane. We're extrapolating from the technology we have on the 707, and we're confident we can manage it."

He stood up and walked to the windows. "For all practical purposes, you are sitting in the middle of your airplane now. The walls are almost vertical, because the cabin is so wide—twenty feet wide. Nine feet high. For the first time, you'll be in a room, not a tube."

Trippe's response to this *coup de théâtre* was no warmer than a flicker of surprise. The problem was that Heinemann was beginning to describe an airplane that Trippe did not recognize as the one for which he had already signed up. Something novel was being proposed: the volume of the 747's fuselage, and hence its capacity for people and cargo, was a factor of width, not just height and length.

It was Heinemann's ability to convey this simple picture of volume that first brought home to Trippe and his engineers that a fundamental change in the accustomed layout of airplanes was being proposed. In the event, Heinemann's rope trick would prove to mark the beginning of the end for the double-decker. At this point no airplane had been designed around the single-deck fuselage; it existed only as a chimera, a vast beast independent of other essential limbs, like wings and a tail. Trippe would not actually commit himself to the single-decker without seeing it as an actual-size wooden mockup. But eventually the promotional lure of the double-decker would fade in the light of the hyphenated sobriquet that fell from someone's lips and was adopted for the 747: wide-body.

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Why do we connect so poorly with the atmosphere? We seem to understand it pretty well. Scientists produce mathematical approximations of probable atmospheric movement, and know to within a few tens of miles where water is going to become ice, or vice versa. Meteorologists are usually adroit at identifying the rough patches—the advancing hurricane, the impending tornado. The atmospheric horizon is instantaneously global; the big picture, what weather folk call the synoptic view, is well in hand. And yet, we are somehow distanced from what might be called atmospheric reality.

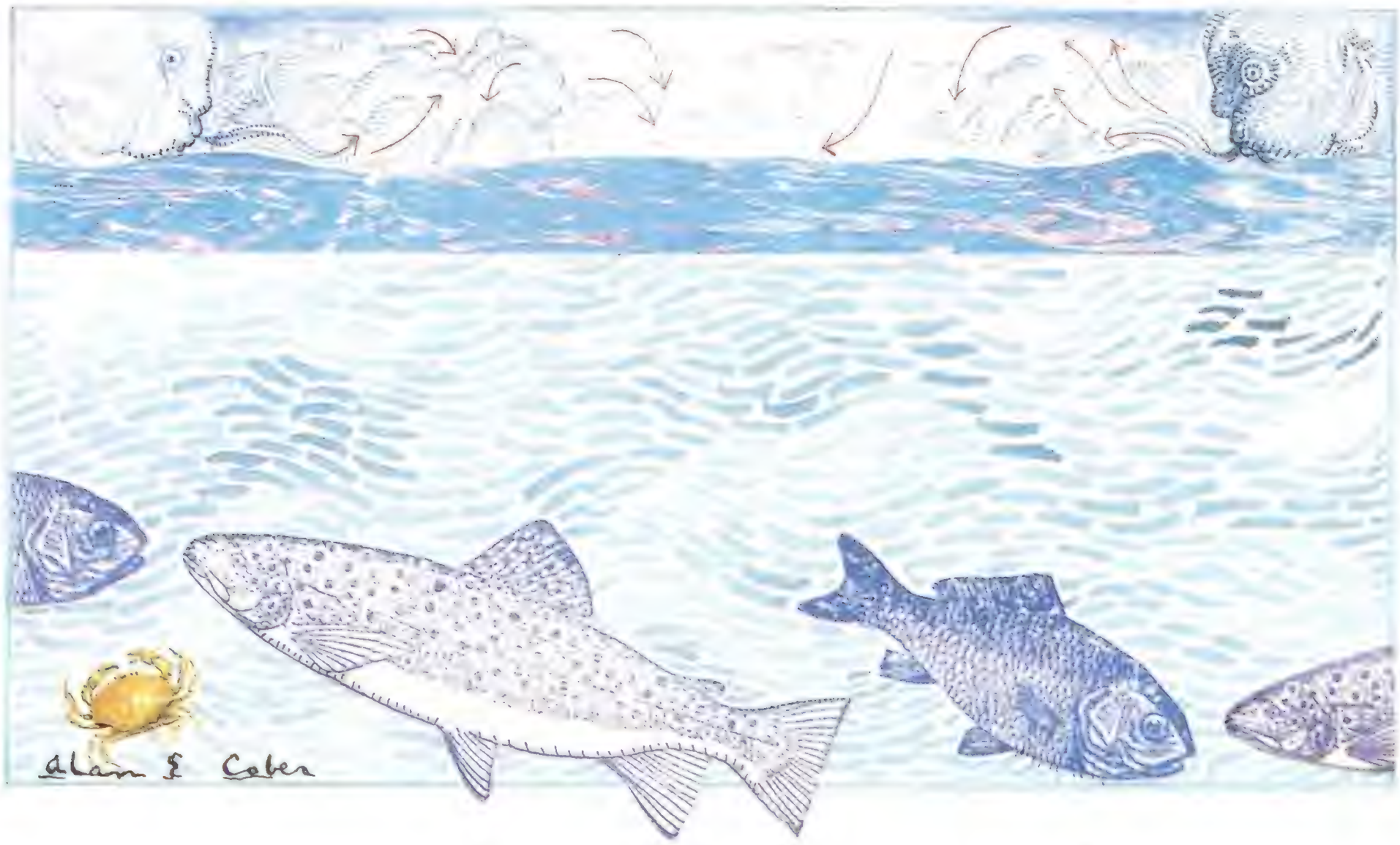
This is not to say we are unable to forecast it. We always have been, to varying degrees, and are no doubt as competent now as at the time of the Civil War to say what the weather over our town will be a week hence.

Forecasting, however, is nowhere near the center of our problem with the atmosphere. It likely does not matter that predictions may—or may not—be improved by more data, or by perfecting the Next technologies—next radars, next satellites, and the like. Perhaps some experts are right to shrug the problem off: given the inherent chaos of the atmosphere, they say, predicting weather will always be a fool's game. And there is a more radical view that questions how much one needs to know about the future atmosphere in the first place. One's life proceeds, fair skies or foul, wet or dry, windy or calm.

What is missing is a keen human sense of how great masses of rising and falling air uncoil across the land, as well as a widespread ability to read the implications of a shift in wind—to see, as a writer in these pages recently said of a glider pilot, "the blue wind flood down...and break against that ridge." In our dealings with the atmosphere, we have largely abandoned metaphor and imagination, the first tools we choose for explorations of an unfamiliar world. We are unable to comprehend what we have lost the ability to imagine. Like denizens of the Mindanao Deep, we read the atmosphere, and the events called weather, from the bottom of a sea.

Weather, to us, is something that sweeps over this ocean's floor, making us warmer or colder, wetter or drier, and sometimes ripping away what we've stuck into the sediment. Rain and snow—precipitation, as we call it down here—precipitates only when it strikes the bottom. Even the great hurricane is

BOTTOM DWELLERS



depicted as a small two-dimensional curlicue, although its central clouds tower nearly to the stratospheric shallows of our transparent sea.

But we are not much interested in all that three-dimensional stuff going on overhead. Students of the air ocean probe it vertically—instrument-laden balloons rise from our stratum regularly, remote sensors beep a pulse of energy upward, satellites look down on us through the atmosphere. But the emphasis is terrestrial—or, rather, benthic. Even the bold sorties of aviators, who actually live in the atmospheric medium for short intervals, rise only a relatively few feet from the muck, focused mainly upon winds (heads or tails), ceilings (heights of cloud bases), and conditions at the points of ascent and return—points on the floor of the atmosphere.

The pinched perspective of the bottom dweller, even the occasionally airborne one, renders the atmosphere alien and incomprehensible. Watching a parade of capital *H*s and *L*s march across the TV weather map, their barbed tentacles denoting boundaries of air masses, blinds us to what is really happening: the great spools of air feeding one another as they circle areas of higher or lower pressure, a vast drifting terrain of invisible gas, the flow spreading where it descends, narrowing where it rises, all interconnected and perpetual, spun into spirals by the planet's rotation and marked by the watery tracers of clouds—water changing its physical state, gaining or losing energy. Here and there a broad ribbon of air spills across a high ridge, shattering into invisible surf. But we, a species hypnotized and inspired by the breaking of ocean waves, are driven mad by breaking atmospheric ones. Austrians kill themselves during the *föhn*, and, as Raymond Chandler readers know, the benthos of Los Angeles begin to murder each other when the Santa Ana—the Red Wind—blows. Do the suicides in Vienna or the gunmen of L.A. give a moment's thought to the phenomenon propelling them—to the unseen torrent of desiccated, compression-heated air nozzling down through the notches to blast out across a leeward plain?

I doubt it. We seem almost blind to the clearest atmospheric signals. Does anyone take note of the accelerating convergence of air beneath a rising storm cloud or mark that exhilarating moment when the wind reverses before the first fall of rain, spewing a great cough of cold air over the warm ground? Perhaps a few. Who thinks of the jet stream as a hurtling current of high-altitude winds, linked to the surrounding atmosphere through eddies, rips, vortices, and counter-currents? Down in the muck, the stream is just another F/X on the TV weather map.

Here's how bad it is: Discovering very-high-altitude east-west winds that mysteriously reverse direction every couple of years, we named them QBO—quasi-biennial oscillation—winds. Long on science, short on soul. In that spirit we would have called the China Clipper the QPTM, for Quasi-scheduled Pacific Transport Mechanism.

Think how the ocean must appear to a whale, who spends its life ranging vertically from top to bottom, exploring the opaque fluid with highly evolved acoustic senses, and doubtless other kinds as well. Whales do not fret about the day's spot temperatures, the thermal highs and lows, or the boundaries between water masses of different temperatures, salinities, and densities. Instead, they must sense the great fluid clockwork sliding and turning and changing around them, perhaps over great distances. They must see themselves as living in the full three dimensions of their world, reading its gatherings and unfoldings for signs of food, favorable currents, shifts in buoyancy and ballast. Almost certainly they can interpret the flick of a straying cold current, the distant crash of a propagating internal wave. Perhaps such comprehension of their ocean is what those enormous brains are for.

We should be so lucky, a meteorologist might sneer, as to have something as sluggishly well-organized as the sea to forecast. And it is true that the ocean is in some ways easier to read, easier to predict, perhaps, than the protean ocean of air. But volatility is not the crucial difference. Imagination is. Our own enormous brains may be better suited to watching and predicting the movement of the seas, for there we are in a foreground of understanding where an ocean must be imagined to be seen. We are not interested in every drop of water, only the ponderous progress of water masses, vast chemistries, the movement of energy across the planet—the important stuff.

Once it was so for our atmosphere. Think of aboriginal meteorologists, twining the future from strands of myth and observation, and of pioneers like Vilhelm Bjerknes and Carl-Gustaf Rossby, who pulled from the inscrutable Arctic sky an understanding of fronts, air masses, and huge atmospheric waves. Today, the ability to imagine such things seems to have nearly drowned in a flood of satellite images and meteorological trivia. Data, not the raw wind, propels what little remains of the imagination. Or perhaps the trouble is that, when it comes to the water ocean, we are soaring creatures of the stratosphere, while in ours, we are mere bottom dwellers, no longer willing to look up.

—Carl A. Posey

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THE MYTH OF THE EDWARDS MYSTIQUE

In the late 1960s journalist Hunter S. Thompson visited Edwards Air Force Base in California to write about test pilots. The following excerpt is from his report, which originally appeared in the September 1969 issue of Pageant. *Thompson later gained fame as the author of* Fear and Loathing in Las Vegas.

Myths and legends die hard in America. We love them for the extra dimension they provide, the illusion of near-infinite possibility to erase the narrow confines of most men's reality. Weird heroes and mold-breaking champions exist as living proof to those who need it that the tyranny of "the rat race" is not yet final. Look at Joe Namath, they say: he broke all the rules and still beat the system like a gong. Or Hugh Hefner, the Horatio Alger of our time. And Cassius Clay—Muhammad Ali—who flew so high, like the U-2, that he couldn't quite believe it when the drone bees shot him down.

Gary Powers, the U-2 pilot shot down over Russia, is now a test pilot for Lockheed Aircraft, testing newer, more "invincible" planes in the cool, bright skies above the Mojave Desert, in the Antelope Valley just north of Los Angeles. The valley is alive with aviation projects, particularly at Edwards Air Force Base, near Lancaster, where the Air Force tests its new planes and breeds a new, computerized version of the legendary, hell-for-leather test pilot. Air Force brass at Edwards is appalled at the persistence of the old "kick the tire, light the fire, and away we go" image. The key word in today's Air Force, they insist, is "professionalism."

This made my visit to the base a bit tricky. It was painfully obvious, even after an hour or so of casual talk, that the hard-nosed pros on the flight line resented the drift of my conversation—particularly when I asked about things like "dueling societies." The Air Force has never valued

a sense of humor in its career men, and in high-risk fields like flight testing, a sense of the absurd will cripple a man's future just as surely as an LSD habit.

Test pilots are very straight people. They are totally dedicated to their work and not accustomed to dealing with slipshod civilians who seem even faintly disorganized—especially writers. My image was further queered by a painfully cracked bone in my right hand, which forced me to use my left in all formal introductions.

At one point, while talking to two colonels, I lamely explained that I break my hand about once a year. "Last time," I said, "it was a motorcycle wreck on a rainy night; I missed a shift between second and third, doing about seventy on a bad curve."

Zang! That did it. They were horrified. "Why would anybody do a thing like that?" asked Lieutenant Colonel Ted Sturmthal, who had just come back from flying the huge XB-70 across the country at the speed of sound. Lieutenant Colonel Dean Godwin, who is rated, along with Sturmthal, as one of the top test pilots in the Air Force, stared at me as if I'd just produced a Vietcong watch fob.

We were sitting in a sort of gray-plastic office near the flight line. Outside, on the cold, gray runway, sat a plane called the SR-71, capable of flying 2000 m.p.h.—or about 3100 feet per second—in the thin air on the edge of the earth's atmosphere, nearly 20 miles up. The SR-71 has already made the U-2 obsolete; the thrust of its two engines equals the power of 45 diesel locomotives and it cruises at an altitude just inside the realm of space flight. Yet neither Sturmthal nor Godwin would have balked for an instant at the prospect of climbing into the cockpit of the thing and pushing it as high and hard as it could possibly go.

The Air Force has been trying for 30 years to croak the image of the wild-eyed, full-force, "aim it at the ground and see if it crashes" kind of test pilot, and they have finally succeeded. The vintage-'69 test pilot is a supercautious, supertrained, superintelligent monument to the Computer Age. He is a perfect specimen, on paper, and so confident of his natural edge on other kinds of men that you begin to wonder—after spending a bit of time in the company of test pilots—if perhaps we might not all be better off if the White House could be moved, tomorrow morning, to this dreary wasteland called Edwards Air Force Base. If nothing else, my own visit to the base convinced me that Air Force test pilots see the rest of us, perhaps accurately, as either physical, mental, or moral rejects.

I came away from Edwards with a sense of having been to IBM's version of Olympus. Why had I ever left that perfect world? I had been in the Air Force once, and it had struck me then as being a clumsy experiment in mass lobotomy, using rules instead of scalpels. Now, ten years later, the Air Force still benefits from the romantic pilot myth that its personnel managers have long since destroyed.

Prior to World War II, pilots were seen as doomed, half-mythical figures, much admired for their daring, but not quite sane when judged by normal standards. While other men rode trains or chugged around the Earth in Model-Ts, barnstorming pilots toured the nation with spectacular "aviation shows," dazzling the yokels at a million country fairs. When their stunts went wrong, they crashed and

often died. The survivors pushed on, treating death like a churlish, harping creditor, toasting their own legend with beakers of gin and wild parties to ward off the chill. "Live fast, die young, and make a good-looking corpse." That gag got a lot of laughs at debutante parties, but in aviation circles it seemed a bit raw, a little too close to the bone.

It was especially pertinent to test pilots, whose job it was to find out which planes would fly and which ones were natural death-traps. If the others took lunatic risks, at least they took them in proved planes. Test pilots, then and now, put the product of engineers' theories to the ultimate test. No experimental plane is "safe" to fly. Some work beautifully, others have fatal flaws. The Mojave Desert is pockmarked with the scars of failure. Only the new ones are visible; the older scars have been covered over by drifting sand and mesquite brush.

Each funeral means more donations, more friends and survivors, to the "window fund." The Test Pilots' Memorial Window in the chapel is a wall of colorful stained-glass mosaics, paid for with donations that otherwise might have gone into the purchase of short-lived flowers. The original idea was to have only one memorial window, but each year invariably brought more donations, so that now there are only a few plain windows left. All the others have been replaced by stained-glass memorials to the 100 names on the plaque in the chapel hallway.

Two or three new names are added each year, on the average, but some years are worse than others. There were no flight-test fatalities in either 1963 or 1964. Then, in 1965, there were eight. In 1966, the death count dropped to four, but two of these occurred on a single day, June 8th, in a mid-air crash between a single-seat fighter and one of the only two XB-70 bombers ever built.

That was a very bad day on Edwards. Test pilots are very close: they live and work together like a professional football team; their wives are good friends, and their children are part of the same small world. So a double fatality shatters everybody. Today's test pilots and their families live nearly as close to death as the old-time pilots ever did—but the new breed fears it more. With rare exceptions, they are married, with at least two children, and in their off-duty hours they live as carefully and quietly as any physics professor. A few ride little Hondas, Suzukis, and other midget motorcycles, but strictly for transportation—or, as one of the pilots explained, "So Mama can use the family car." The flight-line parking lot, where working pilots leave their cars, looks no different from any supermarket lot in San Bernardino. Here again, with rare exceptions, the test pilot's earthbound vehicle is modest—probably a five-year-old Ford or Chevy, perhaps a Volkswagen, Datsun, or other low-priced import. At the other end of the flight line, in front of the test pilots' school, the mix is a bit livelier. Of the 46 cars I counted there one afternoon, there was one Jaguar XKE, one IK-150, one old Mercedes with a V-8 Chevy engine, one Stingray; all the rest were clunkers. A cluster of motorcycles stood near the door, but the hottest one in the lot was a mild-mannered 250 Yamaha.

The midnight roads around Antelope Valley are quiet these days, except for an occasional teen-age drag race. Today's test pilots go to bed early, and they regard big motorcycles with the same analytical disdain they have for hippies, winos, and other failure symbols. They take their risks, on assignment, between dawn and 4:30 p.m. But when their time is their own, they prefer to hunker down in the wall-to-wall anonymity of their one-story, flat-

roofed, Levittown-style homes between the base golf course and the officers' club, there to relax in front of the tube with a succulent TV dinner. Their music is Mantovani, and their idea of an "artist" is Norman Rockwell. On Friday afternoons, from four-thirty to seven, they crowd into the officers' club bar for the weekly "happy hour," where most of the talk is about planes and current test projects. Then, just before seven, they go home to pick up their wives and dress for dinner, again at "the club." After dinner there will be a bit of dancing to the jukebox or maybe a small combo. Heavy drinking is out of the question; a drunken test pilot is viewed with genuine alarm by the others, who see any form of social excess—drink, wenching, late hours, any "unusual" behavior—as an indication of some deeper problem, an emotional cancer of some kind. Tonight's juicer is tomorrow's—or Monday's—hangover risk, a pair of slow-focusing eyes or an uncertain hand at the controls of a $100 million aircraft. The Air Force has trained three generations of elite-level pilots to abhor any hint of foreseeable human risk in the flight-test program. The planes, after all, are risky enough, they are the necessary unknown factor in the equation that every project ideally boils down to. (Test pilots are very hip to equations; they can describe a plane and all its characteristics, using nothing but numbers.) And a cool waterhead knows that an equation with only one unknown factor is a hell of a lot simpler to cope with than an equation with two. The idea, then, is to minimize the chance of a second unknown factor—such as an unpredictable pilot—that might turn a simple flight-test equation into a scorched crater on the desert and another wave of donations to the "window fund."

The Air Force is very keen on people who "go by the book," and there is, in fact, a book—called a technical order—on every piece of equipment in use, including planes. Test pilots can't "go by the book," however, because for all practical purposes, they are the people who write it. "We push a plane to its absolute limits," said a young major at Edwards. "We want to know exactly how it performs under every conceivable circumstance. And then we explain it, on paper, so other pilots will know what to expect of it."

A sense of elitism is pervasive among test pilots. There are less than 100 of them on Edwards, with several hundred more spreading out on testing projects from coast to coast. But Edwards is the capital of their world. "It's like the White House," says recently retired Colonel Joseph Cotton. "After Edwards, the only direction a test pilot can go is down; any other assignment is practically a demotion."

Colonel Cotton is the man who saved one of the $350 million experimental XB-70s by short-circuiting a computer with a paper clip. The huge plane's landing gear had jammed, making it impossible to land. "You can't argue with a black box," said the colonel, "so we had to fool it." While the plane circled the base and engineers on the ground radioed careful instructions, Joe Cotton took a flashlight and a paper clip and crawled into the dark landing-gear bay to perform critical surgery in a maze of wires and relays.

Incredibly, it worked. He managed to short the faulty circuit out of the chain of command, as it were, and trick the computer into lowering the landing gear. The plane landed with locked brakes and flaming tires, but no serious damage—and "Joe Cotton's paper clip" was an instant legend.

I found Colonel Cotton at his new home in Lancaster, pacing around his living room while his wife tried to place a call to a fellow pilot whose teen-age son had been killed the day before in a motorcycle accident. The funeral was set for the next afternoon, and the whole Cotton family was going. (The flight line was empty the next day. The only pilot in the test-operations building was a visiting Britisher. All the others had gone to the funeral.)

Joe Cotton is 47, one of the last of the precomputer generation. By today's standards, he wouldn't even qualify for test-pilot training. He is not a college graduate, much less a master of advanced calculus with an honors degree in math or science. But the young pilots at Edwards speak of Joe Cotton as if he were already a myth. He is not quite real, in their terms: a shade too complex, not entirely predictable. At a recent symposium for the Society of Experimental Test Pilots, Colonel Cotton showed up wearing a Mickey Mouse wristwatch. All the other pilots thought it was "great"—but none of them rushed out to buy one for themselves.

Joe Cotton is a very gentle, small-boned man with an obsessive interest in almost everything. We talked for nearly five hours. In an age of stereotypes, he manages to sound like a patriotic hippie and a Christian anarchist all at once.

"The greatest quality you can build into a plane," he says, "is the quality of forgiveness." Or: "Having control of that airplane is like having control of your life; you don't want it wandering around up there, trying to get into a spin and crash...."

"Flight testing is a beautiful racket... Being a test pilot on the Mojave Desert in America is the greatest expression of freedom I can think of...." And suddenly: "Retiring from the Air Force is like getting out of a cage...."

It is always a bit of a shock to meet an original, unfettered mind, and this was precisely the difference between Colonel Cotton and the young pilots I met on the base. The Air Force computers have done their work well: They have screened out all but the near-perfect specimens. And the science of aviation will benefit, no doubt, from the ultimate perfection of the flight-test equation. Our planes will be safer and more efficient, and eventually we will breed all our pilots in test tubes.

Perhaps it will be for the best. Or maybe not. The last question I asked Joe Cotton was how he felt about the war in Vietnam, and particularly the antiwar protests. "Well," he said, "anytime you can get people emotionally disturbed about war, that's good. I've been an Air Force pilot most of my life, but I've never thought I was put on earth to kill people. The most important thing in life is concern for one another. When we've lost that, we've lost the right to live. If more people in Germany had been concerned about what Hitler was doing, well...." He paused, half-aware—and only half-caring, it seemed—that he was no longer talking like a colonel just retired from the U.S. Air Force.

We walked outside, and when Joe Cotton said good night, he smiled and extended his left hand—remembering, somehow, after all that rambling talk, that I couldn't use my right.

The next afternoon, in the officers' club bar, I decided to broach the same question about the war in a friendly conversation with a young test pilot from Virginia, who had spent some time in Vietnam before his assignment to Edwards. "Well, I've changed my mind about the war," he said. "I used to be all for it, but now I don't give a damn. It's no fun anymore, now that we can't go up north. You could see your targets up there, you could see what you hit. But hell, down south all you do is fly a pattern and drop a bunch of bombs through the clouds. There's no sense of accomplishment." He shrugged and sipped his drink, dismissing the war as a sort of pointless equation, an irrelevant problem no longer deserving of his talents.

An hour or so later, driving back to Los Angeles, I picked up a newscast on the radio: Student riots at Duke, Wisconsin, and Berkeley; oil slick in the Santa Barbara Channel; Kennedy murder trials in New Orleans and Los Angeles. And suddenly Edwards Air Force Base and that young pilot from Virginia seemed a million miles away. Who would ever have thought, for instance, that the war in Vietnam could be solved by taking the fun out of bombing?

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ASLEEP ON BATTLESHIP ROW

NATIONAL ARCHIVES

Pearl Harbor: Final Judgement *by Henry C. Clausen and Bruce Lee. Crown, 1992. 485 pp., b&w photos, $25.00 (hardbound).*

Americans entered World War II with a battle cry ringing in their ears: "Remember Pearl Harbor!" They need not have worried. Half a century later, it is clear that we are not about to forget the events of December 7, 1941. Pearl Harbor, like the encounter between two cultures on the banks of the Little Bighorn, poses a fundamental question for a people who regard themselves as the ultimate winners: "How can such a thing have happened?"

An ocean of ink has been spilled in attempts to solve the riddle and apportion the blame for the greatest military disaster in American history. Readers can pick and choose from a veritable smorgasbord of conspiracy theories. We are told that Pacific airwaves were alive with mysterious radio messages warning of an attack, that U.S. Naval intelligence actually tracked the Japanese fleet across the North Pacific, that the British, the Russians, and even the president of the United States knew that the attack was coming and did nothing about it. If we were to add all of the theories up, we could only conclude that everyone except the captain of the USS *Arizona* was in on the secret.

In *Pearl Harbor: Final Judgement,* Henry Clausen sweeps all of the nonsense and speculation aside to provide us with a rational account of what actually occurred during the months, weeks, days, and hours prior to the attack. He is a man who knows whereof he speaks. In November 1944, Secretary of War Henry Stimson ordered Clausen, then a major in the Army Judge Advocate General's Corps, to conduct an investigation that would leave "no stone unturned" in an attempt to discover what had gone wrong and to fix responsibility for the disaster.

A veteran trial lawyer, the author approached the task like a grand jury investigator. He traveled 55,000 miles through the United States, Europe, and the Pacific, locating and studying the relevant documents and taking depositions from men and women who might be able to shed light on the situation prior to the attack. Clausen delivered his final report to Secretary Stimson in September 1945. His recommendations were, for the most part, accepted by the War Department and a Congressional investigating committee. The report itself, which revealed the full extent of U.S. code breaking activities, was stamped top secret, filed away, and forgotten.

Clausen's first-person account of his investigation has all the excitement of a good thriller. Piece by piece, the evidence falls into place and a picture begins to emerge. There is no need for a grand conspiracy. The American failure to prepare for a possible attack on Pearl Harbor was the result of errors, jealousies, and catastrophic mistakes in judgement.

The author demonstrates that there was plenty of blame to go around. Washington officials did not do a particularly good job themselves as to the state of readiness in Hawaii. Interservice rivalry prevented Army and Navy intelligence officials in Washington and Hawaii from sharing vital information.

Clausen reveals that the famous 14-part message from Tokyo to the Japanese Embassy in Washington severing diplomatic relations was actually in American hands on the evening of December 6. The officer responsible for circulating the translated intercept to key decision-makers simply failed to recognize the importance of the message and did not distribute copies until the next morning.

If things were bad in Washington, they were worse in Hawaii. Clausen argues that Admiral Husband E. Kimmel and General Walter C. Short, the Navy and Army commanders in Hawaii, must bear the ultimate responsibility for the lack of preparedness. While Washington might

have done a better job of communicating, the local commanders had received ample warning of the danger. Kimmel and Short were "sentries asleep at their posts." They failed to coordinate their efforts, failed to make full use of vital new technology such as radar, and failed to take reasonable precautions based on the information available to them.

The author makes a persuasive case. In point of fact, this book has the rare distinction of delivering on the promise of its title. It is as close as we are likely to come to a "final judgement" on the matter of Pearl Harbor.

—Tom Crouch is chairman of the aeronautics department at the National Air and Space Museum.

She Went to War: The Rhonda Cornum Story *by Rhonda Cornum, as told to Peter Copeland. Presidio Press, 1992. 203 pp., b&w photos, $19.95 (hardbound).*

RHONDA CORNUM, *SHE WENT TO WAR*

Stereotypes thrive on the absence of information. When the subject is women in combat, the lack of information remains close to total and the stereotypes are piled thick enough to suffocate any reasonable analysis. This brisk and dramatic memoir of the Gulf war by Major Rhonda Cornum, an Army flight surgeon who gained fame after being imprisoned in Iraq when her helicopter was shot down on a search-and-rescue mission, should offer a bracing antidote. Major Cornum's courage and common sense during her captivity, and later in Washington where she went public—but far from hysterical—with the details of her sexual assault at the hands of an Iraqi guard, provide a counterexample to demeaning preconceptions of how women act under pressure, how they react to physical and psychological challenge and danger, and (this last stereotype coming as much from the left as from the right) how they feel about war and violence.

Rhonda Cornum, trained as a scientist and then as a flight surgeon, full of zest for what she does and also, unembarrassedly, for the mind- and body-stretching challenges of wartime, bears little relation to any such stereotype. When she was asked to go to the Gulf she was 36, married to an Air Force surgeon (he also wound up in Saudi Arabia, but not in action), and mother of a 14-year-old daughter from a previous marriage. One of the only times her gender had proved inconvenient, she writes, was during an officer evaluation, when a colonel told her, "You know, Rhonda, if you were a man, you could be a general." (She answered, "Thank you very much, sir; some of us will just have to live with these physical handicaps.") In the Gulf, though, her medical skills were so well respected that the crew of the helicopter going on the search-and-rescue mission requested her specifically. Five of the crew of eight were killed when the helicopter was shot down; Cornum survived the crash and was taken prisoner with two broken arms, an injured knee, and a bullet wound in her shoulder. The war was just ending, and it was several confusing days, with the Iraqis shifting her and a few others from prison

MUSIC

Murmurs of Earth: The Voyager Interstellar Record, *Warner New Media. CD set with 273-pp. book, $79.98.*

Fifteen years ago NASA launched the two Voyager planetary probes into space, each carrying a disc encoded with musical, verbal, and visual accounts of both our human condition and our planetary status. There were 122 images (from a solar location map to the Taj Mahal to a roster of the U.S. Congress), greetings in 55 languages (plus "Whale Greetings"), "Sounds of Earth" from "Volcanoes, Earthquakes, Thunder" to "Kiss," and 27 musical compositions. All are included on these CD-ROM discs; for those without CD-ROM capability, the photos are included in the 273-page book that accompanies the two CDs, which run more than two hours.

What concerns us here is the audio portion of this—what? self-portrait of a species for examination by our alien brothers and sisters, or mirror image for us to examine for clues about ourselves? There is some unintended comedy, black and otherwise, in the opening verbal section that begins with a hello from then-U.N. Secretary General Kurt Waldheim. Later there's Wallace R.T. Macaulay, U.N. delegate from Nigeria: "My dear friends in outer space—as you probably know, my country is situated in the west coast of the continent of Africa, a landmass more or less in the shape of a question mark...." Then to the music, which kicks off with J.S. Bach's Brandenburg Concerto Number 2 in F, First Movement, conducted by Karl Richter and performed by the Munich Bach Orchestra. It is possibly the worst Bach recording currently available anywhere—shrill, screeching, brittle, metallic, inhuman. Except for occasional relief from digital versions of the original Voyager masters for *Tchenhoukoumen* (Senegalese percussion), Louis Armstrong's 1927 *Melancholy Blues*, and a very few more, the same disaster recurs throughout the series. With Chuck Berry's *Johnny B. Goode* the sound is so distorted it all but collapses into itself, destroying all detail.

This is so because, as a person associated with the original production team has confirmed, the musical selections were not remastered for this release. Instead, a third-generation quarter-track studio dub was used, and this inferior artifact was itself badly transferred from analogue to digital. The result has virtually no value as something to listen to and only marginal documentary value. An authentically remastered video disc is still a possibility—wait for that.

In this morass, which might well be retitled "Garbles of Earth," there is one shining exception: the stunning segue from the ancient Chinese Ch'in piece *Flowing Streams*, performed by Kuan P'ing-hu, to the raga *Jaat Kahan Ho* by Surshri Kesar Bai Kerkar, to *Dark Was the Night*, the overwhelming 1927 wordless blues by Blind Willie Johnson. For once the sound is clear for more than a track at a time, and the music is so deep, so quietly passionate, so hypnotic, that one can begin to drift away from any knowledge one might bring to it. One can, if just for a moment, begin to imagine what someone—something—else might make of what we as a species have to say. Just as there is no extant recording of *Johnny B. Goode* as bad as this one, I don't know of any anthology that matches the reveries of this conversation.

—Greil Marcus is the author of Lipstick Traces, Mystery Train, *and* Dead Elvis.

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to prison and city to city, before she took stock of these injuries, got rudimentary treatment, and was turned over to the Red Cross.

Her description of these trials is level-headed, as are her explanations of why the ordeal was worth it. "I could not have articulated this desire to face the ultimate challenge," she writes. "But now I know it's true. I never hoped for bad things to happen, and I certainly didn't want anyone to be hurt, but if there was going to be a war, I wanted to be there and do my part." A plain and admirable enough sentiment, and it anchors a tale well worth telling.

—Amy E. Schwartz writes for the Washington Post.

Is Anyone Out There? *by Frank Drake and Dava Sobel. Delacorte Press, 1992. 272 pp., b&w photos, $22.00 (hardbound).*

The fact that NASA has finally begun to search for extraterrestrial intelligence in a coherent way owes much to many scientists and engineers, but to no one more than Frank Drake, who has been encouraging humanity's SETI efforts since his days as a graduate student. For more than three decades, Drake has occupied the center of gravity of serious SETI efforts. *Is Anyone Out There?,* the story of his scientific career, places special emphasis on SETI. He caught the SETI bug as an undergraduate at Cornell University in 1951, when he heard the famous astronomer Otto Struve say that life could exist in many places throughout our Milky Way galaxy. He went on to become a prominent radio astronomer, serving as director of the National Astronomy and Ionosphere Center (which operates the 1,000-foot radio dish near Arecibo, Puerto Rico) and as the dean of natural sciences at the University of California in Santa Cruz, where he is now a professor of astronomy and astrophysics.

Drake is probably best known to the public for the "Drake Equation," his attempt to organize our knowledge and our ignorance in estimating the number of civilizations in our galaxy, and for Project Ozma, the first radio search for another civilization, which he undertook in 1960 at the Green Bank observatory in West Virginia. Readers of this captivating memoir will learn what it was like to work in Appalachia with a man named French Beverage (whom Drake once considered sending out to buy champagne), how it felt to learn of several possible messages from extraterrestrials (all of which turned

out to be false alarms), and what such highly charged personalities as Carl Sagan, Barney Oliver, and Philip Morrison have to say when they consider how best to search for extraterrestrial life.

Anyone who enjoys thinking about the search for other civilizations—where it has been and where it may go—will profit from reading *Is Anyone Out There?*, which includes not only a good scientific account of SETI but also a host of entertaining anecdotes. Some of the best parts of the book deal with the efforts to convince the U.S. Congress that SETI is worth supporting—a difficult task in light of what is now called the "giggle factor." Another amusing anecdote details a visit with Timothy Leary in prison (he wanted to know how to build a starship to carry humanity to new worlds). If each of us had as fine a tale to tell as Frank Drake, we should be rich in accomplishment—and in the informed speculation that makes accomplishment the more rewarding.

—Donald Goldsmith recently co-authored (with Tobias Owen) The Search for Life in the Universe, second edition *(Addison-Wesley).*

Where is Joe Merchant? *by Jimmy Buffet. Harcourt Brace Jovanovich, 1992. 382 pp., $19.95 (hardbound).*

Reading *Where is Joe Merchant?*, singer Jimmy Buffet's best-selling first novel, is like sitting in a Margaritaville saloon while a likable stranger spins a rambling, loosely structured yarn about Caribbean life, flight, magic, and the stars. Pilot Frank Bama, not quite earning his way with *Hemisphere Dancer*, the Grumman Goose he discovered along the Orinoco and restored, finds himself entangled with both the bank and the law. Poised to run for Alaska, Bama is deterred by the return of beautiful Trevor Kane, an erstwhile lover and the sister of drug-soaked rock star Joe Merchant, who a year earlier had vanished into the Black Sea, a presumed suicide. Trevor believes Joe is still alive and wants Bama to help her find him.

The author, according to his publisher, flies a Lake Renegade amphibian and clearly has a head filled with the beauty of such aviation—the tongues of deep blue water curled among jade flats, submerged formations of migrating rays, protean weather blossoming and withering everywhere. There is some fine flying as well. Bama makes an open-ocean landing in a heaving swell that illustrates why amphibs keep mostly to sheltered waters, and a takeoff through pounding surf with one wing float missing has a good ring to it. On the down side, the ganders at the Goose are often perfunctory, and the

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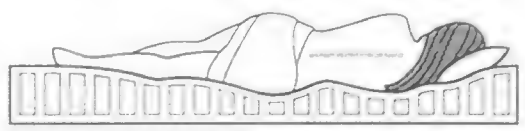

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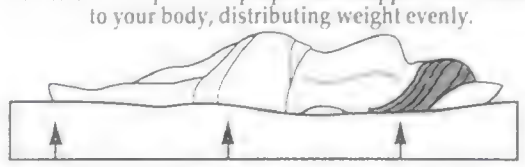

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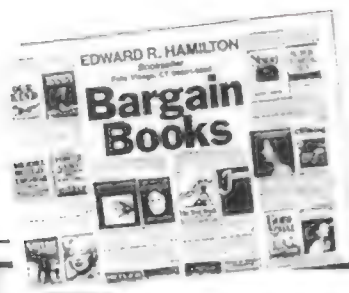

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author puts his hero into a Paulinesque aeronautical peril from which rescue is simply impossible. As for the mystery posed in the title, readers unable to answer the question long before the author does it for them are just not following the cards.

—Carl A. Posey is an erstwhile seaplane pilot.

The Art of Robert McCall, *introduction by Ray Bradbury. Bantam, 1992. 150 pp., color illustrations, $60.00 (hardbound).*

Robert McCall's work presents a vision of the future that offers the kind of grandiose heroic imagery not seen in this country since the WPA funded artists to decorate public buildings. And it is just this melding of unabashed sentimentality and blatant symbolism with the otherwise cold-blooded imagery of astronomy and high technology that has made McCall the Norman Rockwell of the Space Age.

This appellation is attached with the sincerest attempt at flattery; McCall's all-American naïveté is what makes his art so accessible and, in seeming contradiction, so emotionally profound. There are no convoluted subtleties in this book, only punches straight to the heart. McCall doesn't mess around. For all its teetering on the brink of kitsch, for all its baroque flamboyance, it grabs you by the collar and gives you a good shake.

There are disappointments with the book: an absence of McCall's early work, perhaps a surfeit of often-reproduced images, and a repetitiveness of futuristic cityscapes. However, the drawbacks are more than offset by the many luminous two-page spreads. There's also a marvelous introduction by Ray Bradbury, one of the few writers—if not the only one—who have a grasp of what space art is really all about. If you like space art at all, or if the vision of mankind's future in space makes your pulse race, then you must own this book.

—Ron Miller is a space artist and contributing editor to Air & Space/ Smithsonian.

FILM

A Brief History of Time, *directed by Errol Morris. Based on the book by Stephen Hawking. Released by Triton Pictures.*

Stephen Hawking's cosmological tome, *A Brief History of Time,* may be the world's least read best seller. The millions who bought it, perhaps hoping to find a user's guide to the universe, were often turned off by its complex mathematics. Yet director Errol Morris, who also directed the controversial documentary *The Thin Blue Line,* decided to tackle this unlikely subject nonetheless, and has succeeded in creating an entertaining and informative movie from it.

In order to make the material much less daunting, Morris concentrated more on Hawking himself. Commercially that was probably a wise decision. Had Hawking not existed, Hollywood no doubt would have invented him. A gifted if lackadaisical student, Hawking at 25 was stricken with amyotrophic lateral sclerosis, or Lou Gehrig's disease, which served to focus his intellectual energies. He has since become almost a living symbol: the brilliant mind imprisoned in a decaying body. His story is compelling enough to draw in those with little interest in cosmology. Yet anyone who sees the movie to learn about the universe—where it came from, where it's going, and what the heck happens in a black hole—may be frustrated by the emphasis on Hawking. And those interested in Hawking may find the cosmology an irritant.

As entertainment the movie largely succeeds, thanks to the humor provided by the talking heads Morris interviews and by Hawking, who narrates much of the film with his computer-generated voice synthesizer. The mechanical voice not only helps to heighten the sense that Hawking is on a plane other than ours, it also manages to communicate his dry, deadpan wit. *A Brief History of Time* may not provide a full understanding of cosmology, but it does teach a little something about everything—and quite a bit about Stephen Hawking.

—Tom Huntington is the managing editor of Air & Space/Smithsonian.

CALENDAR

November 7–December 6
"Vietnam Veterans Memorial: A National Experience." Smithsonian Traveling Exhibition. Colquitt County Art Center, Moultrie, GA, (912) 985-1922.

November 28–December 27
"Steichen and His Men: A Photographic Portrait of World War II." Smithsonian Traveling Exhibition. Birmingham Public Library, Birmingham, AL, (205) 226-3600.

November 28–January 3
"The View From Space: American Astronaut Photography, 1962–1972." Smithsonian Traveling Exhibition. St. Louis Public Library, St. Louis, MO, (314) 241-2288.

January 1
"Sno'Fly: The First Kite Fly of the Year." Sponsored by the Kalamazoo County Parks Department. Ancient Japanese kite fighting on ice, stunt kite pilots, kite skiers, kite sledders, ice skating, ice fishing. Contests for: best decorated line, "most excellent hat," "awesomest earmuffs." Prairie View Park, Kalamazoo, MI, (616) 383-8778.

January 2–February 21
"Vietnam Veterans Memorial: A National Experience." Smithsonian Traveling Exhibition. Tulsa Junior College, Tulsa, OK, (918) 631-7226.

January 16–April 4
"Steichen and His Men: A Photographic Portrait of World War II." Smithsonian Traveling Exhibition. Fresno Metropolitan Museum, Fresno, CA, (209) 233-2121.

January 17
"Open Cockpit Sunday." World War II and modern fighters, bombers, helicopters. New England Air Museum, Bradley International Airport, Windsor Locks, CT, (203) 623-3305.

January 23–February 28
"The View From Space: American Astronaut Photography, 1962–1972." Smithsonian Traveling Exhibition. Virginia Museum of Natural History, Martinsville, VA, (703) 666-8600.

January 30–March 14
"All Systems Go: America's Space Transportation System for the 1990s." Smithsonian Traveling Exhibition. McCallen International Museum, McCallen, TX, (512) 682-1564.

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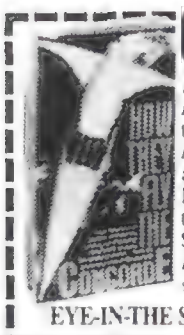

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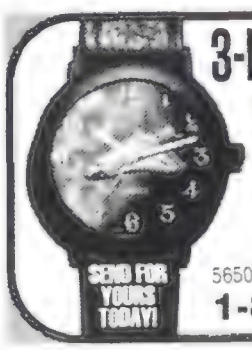

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CREDITS

Sir Richard's Wild Ride. Contributing editor Ron Dick's last contribution to *Air & Space/Smithsonian* was "The Shack" (April/May 1992).

T Minus Me. Donald Groff is a travel writer based in Philadelphia.

Iced Lightning. Karen Jensen is an associate editor of *Air & Space/Smithsonian.*

Further reading: *War Below Zero: The Battle for Greenland,* Colonel Brent Balchen, Major Corey Ford, and Major Oliver La Farge, Houghton Mifflin, 1944.

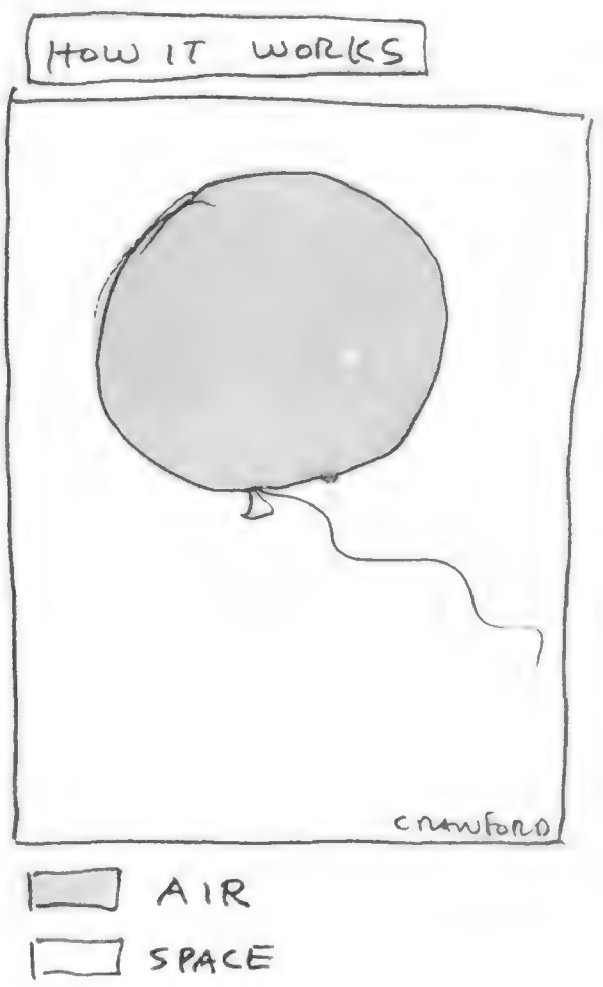
The Greenland Expedition Society can be reached at: Epps Aviation, DeKalb-Peachtree Airport, Suite 1, Atlanta, GA 30341.

Let There Be Light. Andrew Chaikin, a long-time stargazer, is a frequent contributor to *Air & Space/Smithsonian.*

The Return of the Mighty Eighth. Stephen Bloomfield is a freelance journalist and private pilot who regularly flies from and over some of the old fields that the Eighth Air Force used in England.

Further reading: *One Last Look: A Sentimental Journey to the Eighth Air Force Heavy Bomber Bases of World War II in England,* Philip Kaplan and Rex Alan Smith, Abbeville Press, 1983.

The Mighty Eighth: Units, Men and Machines, a History of the U.S. 8th Army



Air Force, Roger Anthony Freeman, Doubleday, 1970.

A 12-Pack of Pictures. George C. Larson is the editor of *Air & Space/ Smithsonian*.

The Einstein Test. Frank Kuznik is a frequent contributor to *Air & Space/ Smithsonian*.

Wide-Body. Clive Irving is a member of the editorial staff of *Condé Nast Traveler* magazine.

Further reading: *The Jet Makers, The Aerospace Industry from 1945 to 1972*, Charles D. Bright, The Regents Press of Kansas, 1978.

Bottom Dwellers. Carl A. Posey, a Washington-based writer, wrote "The Drug Fight" in the December 1991/January 1992 issue.

The Treasures of Beijing. Private pilot John Zollinger works for a Chinese news agency in Beijing.

For more information about the calendars in "A 12-Pack of Pictures":

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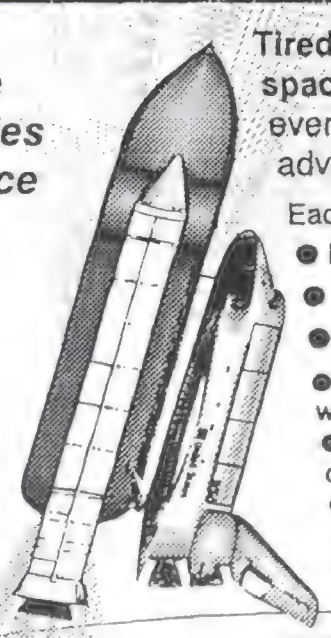

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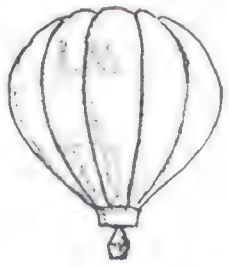

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FORECAST

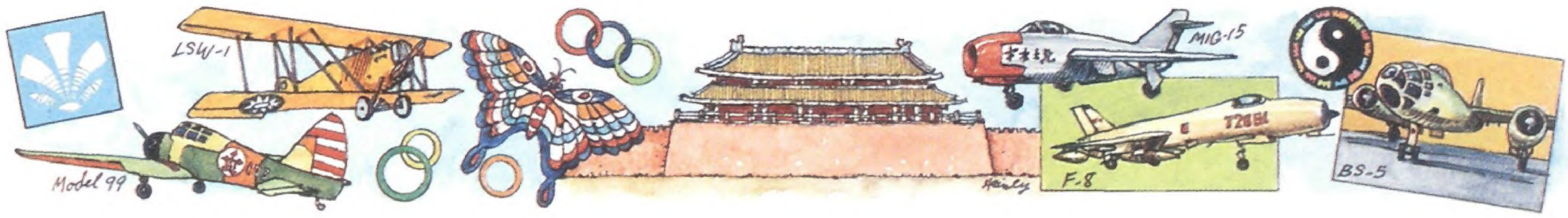
In the Wings...

Long Haul for the Spruce Goose. When Howard Hughes' giant seaplane was sold last summer, it had to be moved up the coast from southern California to McMinnville, Oregon. A few of the men who had built it were on hand to lovingly take it apart.

Shadow of the V-2. Often disguised by its later glory as the ancestor of space rockets and the U.S. moon shot, Wernher von Braun's V-2 is also a symbol of Nazi terror and cruelty. Recent plans to memorialize the scientific achievement at its Peenemünde birthplace have once again provoked controversy over how Germans should remember their past.

Oshkosh, Here I Come. Of course you think the airplane you built with your own hands is the greatest thing since sliced bread. But the judges awarding the prizes at the Experimental Aircraft Association's Annual Convention and Fly-In have a different set of criteria.

A Measure of Security. How safe are the world's airlines? Experts in airport security, including a former terrorist, examine the soft spots in the hard job of fighting terrorism in the air.



JOHN HEINLY

THE TREASURES OF BEIJING

On a crisp autumn day in the suburbs of Beijing, peasants rake out thousands of bushels of grain to dry on the vast concrete taxiways at Da Tangshan Air Base. Then they deftly sweep their bounty with stalk brooms, shunting stray seeds back to the piles. Looming behind the taxiways on which the farmers toil is the great Da Tangshan rock formation, which towers several hundred feet above the plain. Dozens of aircraft, of all different makes and nationalities, line the ramps and hangar access, many of them never having been this close to one another except when locked in mortal combat.

Welcome to China's premier aviation museum.

Built in the late 1960s and early '70s, Da Tangshan Air Base was intended as a home for 20 Ilyushin Il-18 aircraft, part of a defense web protecting Beijing from Soviet attack. But the facility, which includes a 1,620-foot-long tunnel hollowed out of the stone mountain, never became active. A slackening of the Soviet military threat, coupled with chronic dampness in the tunnel, scrubbed the base's mission by the early '80s.

For years the station remained abandoned. Then the government decided to turn Da Tangshan into a first-class aviation museum. The task was given to Xue Pei Sen, a former manager of a weapons system research institute and now a colonel in the People's Liberation Army Air Force reserves. Since 1987 Xue has built offices and solicited the equivalent of over $2.5 million in funding from various armed forces units. He has located dozens of airplanes and transported them to Beijing, either by flying them or by disassembling them and shipping the parts by train.

Downplaying his efforts, the director rebuffs attempts to be put in the limelight. Following a Chinese philosophy of putting the group before the individual, Xue draws upon a proverb to describe the success of the museum and its 120-person staff: "A just course enjoins abundant support," he says through a translator.

Since its official opening on November 11, 1989, the museum has logged 1.5 million visitors, nearly half of them schoolchildren. During a recent field trip, thousands of kids decked out in yellow school caps raced around the ramps. They shared lunches under the wings of giant bombers, played in the shadow of anti-aircraft cannon, and even nestled under the empennage of Chairman Mao's Li-2 transport.

Da Tangshan Aviation Museum, P.O. Box 5806, Changping County, Beijing, People's Republic of China 102211. Phone 86-1-291-2457, ext. 1142. Open daily, 8:30 a.m. to 5 p.m. Admission: Chinese citizens, 5 yuan. Foreigners, 15 F.E.C. or U.S. $3. Handicapped access, wheelchairs available.

Counting the contents of the tunnel and the outside exhibits, the museum is home to 200 aircraft and over 600 pieces of artillery, bombs, and missiles. Dozens of Soviet- and Chinese-made MiG-15s and -17s line one ramp. On another sit C-46 and C-47 transports. And there are two Soviet-made Tupolev Tu-4 heavy bombers, part of a group of 10 that Stalin gave to Mao in 1953 to celebrate the chairman's 60th birthday. Adding to the museum's allure is its collection of rarities, ranging from China's first flier, the FR II—a Curtiss copy built in 1909—to a 1956 F-5 jet fighter, number 0101, the first MiG-15 made in China.

Da Tangshan is also the final resting place for a Lockheed U-2B spyplane. Its smashed and twisted remains lie scattered outside the tunnel. Tour guide Wan Man Tian says it was shot down on January 10, 1965, over Baotou City, Inner Mongolia.

One of the collection's Chinese jets, an A-5A, has a harrowing story behind it: on December 30, 1971, the aircraft was supposed to test-drop China's first hydrogen bomb. But the bomb-release mechanism didn't work and the pilot faced the nerve-wracking prospect of landing a very heavy aircraft. Ground control had the airfield cleared and the pilot landed safely. A week later the A-5A made a second run and completed its mission.

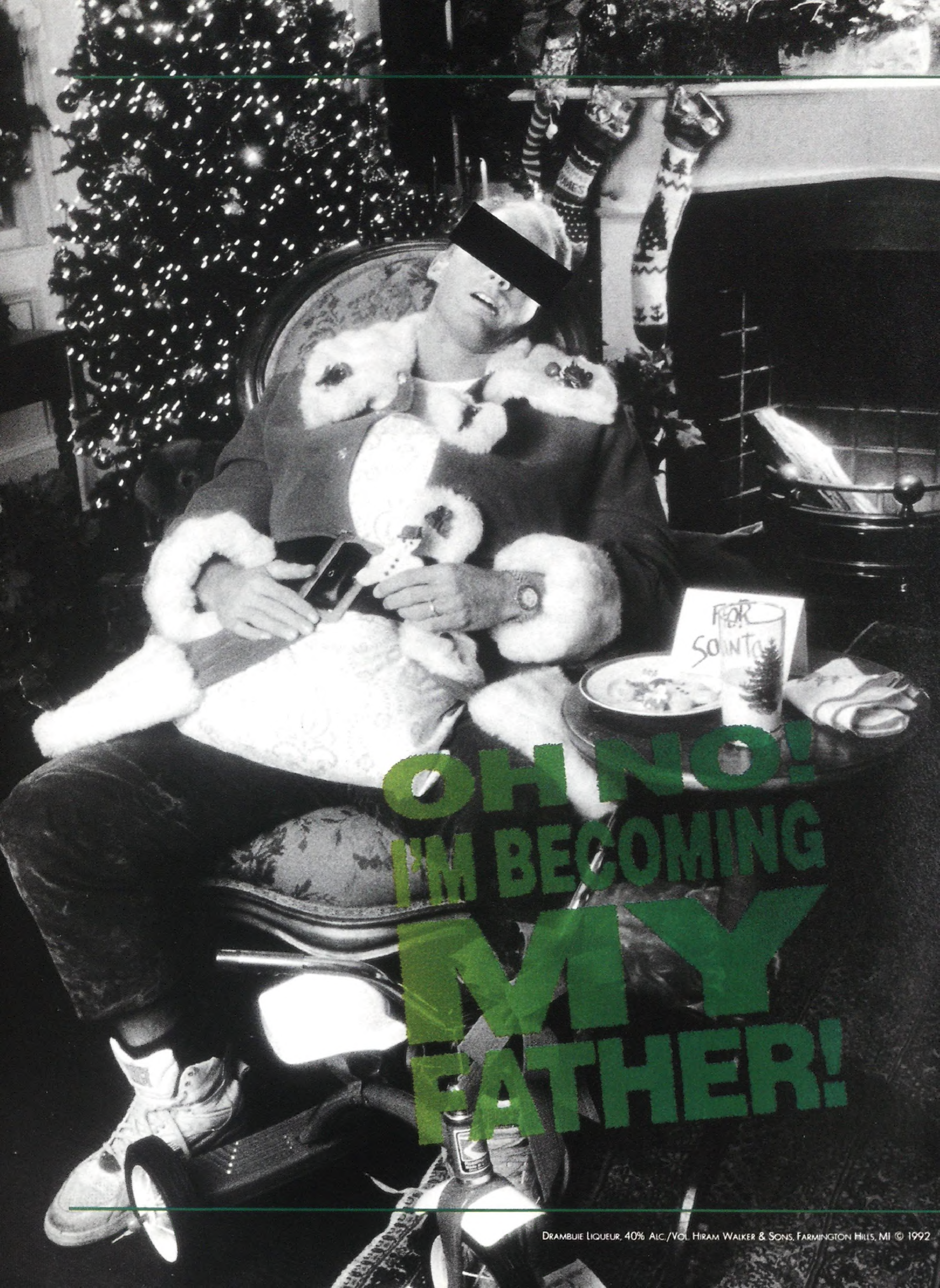
China is a land where spinoffs of Western technology are rampant, and the model 701 helicopter stands as a classic example. According to Xue, the 701 was designed by examining photographs of a Bell 47. The only noticeable difference between the 701 and the Bell is the Chinese use of metal for the majority of the cockpit housing, replacing the Bell's distinctive all-plexiglass fishbowl canopy. But Xue says that the 701's engine is a Chinese design.

Foreign craft—some donated, others captured—line the right side of the tunnel. Scores of World War II Soviet aircraft, stretching along the arched chamber, make up a large portion of the collection, which includes Il-10 fighter-bombers and Tu-2 medium bombers. The origin of two specimens, an L-9 and an L-11, is not too hard to guess: the airplanes are strikingly similar to German FW-190s.

At the far end of the tunnel is an eclectic group of airplanes, among them a Lockheed T-33, a de Havilland of Canada Beaver, and a Cessna 172, all sharing one commonality: Taiwanese defectors flew them or aircraft like them to the mainland.

If there is one down side to the museum, it is a frustrating lack of information about the aircraft. Each artifact is accompanied by only a brief written description in Chinese and English. In some cases the Chinese version spices up the tale, often spinning a more patriotic yarn than its English counterpart. When asked about a given artifact, tour guides—and even Xue himself—usually can't provide much detail, either in terms of general production background or the display's specific history. "We only have a very short history in this museum," says Xue. "For the time being, we concentrate on the hardware part. For the time being, we leave the software as the future part."

—John Zollinger



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